

17/10/11
TRANSACTIONS

OF THE
ROYAL SOCIETY OF EDINBURGH.

VOL. IV.



EDINBURGH:

PRINTED FOR T. CADELL JUN. AND W. DAVIES
(SUCCESSORS TO MR CADELL) IN THE STRAND, LONDON,
AND

J. DICKSON, AND E. BALFOUR, EDINBURGH.

MDCCXCVIII.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOLUME IV.



EDINBURGH.

PRINTED FOR T. WOODHEAD, AND W. DAVIES,
(SUCCESSORS TO MR. GOSWELL) THE STRAND, LONDON.

J. DICKSON, AND E. BALFOUR, EDINBURGH.

MDCCLXXXIII.

CONTENTS

OF THE

FOURTH VOLUME.

PART I.

HISTORY of the SOCIETY.

<i>Four Theorems for resolving all the Cases of Plane and Spherical Triangles, by the Reverend Mr Fisher,</i>	-	Page 4.
<i>Dissertation on the Philosophy of Light, Heat, and Fire, by Dr Hutton,</i>	-	7.
<i>Improvement of the Mercurial Level, by Mr Keith,</i>	-	17.
<i>Experiments on the Effects of Opium on the Living Animal, by Dr Wilson,</i>	-	18.
<i>On the Diurnal Variations of the Barometer, by Dr Balfour of Calcutta,</i>	-	25.
<i>On the Sulphurating of Metals, by Dr Hutton,</i>	-	27.
<i>New Observatory at Aberdeen,</i>	-	29.

APPENDIX.

<i>Office-Bearers of the SOCIETY,</i>	-	31.
<i>LIST of MEMBERS, continued from the third Volume,</i>	-	33.
<i>MEMBERS DECEASED,</i>	-	36.
<i>Donations,</i>	-	38.
<i>I. Biographical Account of Lord Abercromby,</i>	-	(1).
<i>II. Biographical Account of William Tytler, Esq; of Woodhouselee,</i>	-	(17).
<i>III. Biogra-</i>	-	

- III. *Biographical Account of Mr William Hamilton, late Professor of Anatomy and Botany in the University of Glasgow,* Page (35).
 IV. *Biographical Account of John Roebuck, M. D.* - (65).

P A R T II.

PAPERS READ BEFORE THE SOCIETY.

I.

PAPERS OF THE PHYSICAL CLASS.

- I. *Account of a Mineral from Strontian, and of a peculiar Species of Earth which it contains.* By Thomas Charles Hope, Professor* of Medicine in the University of Glasgow, - Page 3.
 II. *Observations on the Natural History of Guiana.* By William Lochead, Esq; - 41.
 III. *On the Principles of the Antecedental Calculus.* By James Glenie, Esq; - 65.
 IV. *Observations on the Trigonometrical Tables of the Brabmins.* By John Playfair, Professor of Mathematics in the University of Edinburgh, - 83.
 V. *Some Geometrical Porisms, with Examples of their Application to the Solution of Problems.* By Mr William Wallace, Assistant-Teacher of the Mathematics in the Academy of Perth, - 107.
 V†. *On the Latitude and Longitude of Aberdeen.* By Andrew Mackay, LL. D. & F. R. S. Edin. - 135.

VI.

* Now Joint Professor of Chemistry in the University of Edinburgh.

† By mistake No. V. is repeated.

- VI. *An Account of certain Motions which small lighted Wicks acquire, when swimming on a Basen of Oil.* By Patrick Wilson, F. R. S. Edin. and Professor of Practical Astronomy in the University of Glasgow, Page, 163.
- VII. *Account of a Singular Halo of the Moon.* By William Hall, Esq; of Whitehall, F. R. S. Edin. - 174.
- VIII. *A New Series for the Rectification of the Ellipsis, with Observations on the Evolution of a certain Algebraic Formula.* By James Ivory, A. M. - 177.
- IX. *Mineralogical Description of the Mountain of Gibraltar.* By Major Imrie. - - 191.
- X. *Description of a Thermometer, which marks the greatest Degree of Heat and Cold from one Time of Observation to another.* By Alexander Keith, Esq; F. R. S. & F. A. S. Edin. - - 203.
- XI. *Description of a Barometer which marks the Rise and Fall of the Mercury from two different Times of Observation.* By Alexander Keith, Esq; F. R. S. & F. A. S. Edin. - - 209.
- XII. *Meteorological Abstract for the Years 1794, 1795, 1796,* - - - 213.

II.

PAPERS OF THE LITERARY CLASS.

- I. *On the Origin and Principles of Gothic Architecture.* By Sir James Hall, Bart. F. R. & A. S. S. Edin. - 3.
- II. M. CHEVALIER's *Tableau de la Plaine de Troye illustrated and confirmed from the Observations of subsequent Travellers and others.* By Andrew Dalzel, M. A. F. R. S. Edin. Professor of Greek in the University of Edinburgh, - - 29.

ADVER-

ADVERTISEMENT.

Edinburgh, February 15. 1798.

At a Meeting of the Council of the Royal Society it was, this day, *Resolved*, That a Publication of Papers, communicated to the Society, shall hereafter be made annually, whether such Papers be sufficient to form an entire Volume, or only a Part of a Volume.

TRANS-

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. IV. PART I.

HISTORY OF THE SOCIETY.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH

VOL. IV. PART I.

HISTORY OF THE SOCIETY

HISTORY

OF

THE SOCIETY.

THE Third Volume of these *Transactions* brings down the History of the Society no farther than the end of the year 1792, though it contains several Papers that are of a later date.

Phys. Cl. Dr MONRO read a paper, entitled, Observations on the Muscles, and particularly on the Effects of the Oblique Fibres. This paper is inserted in the Third Volume of the *Transactions*, Part II. No. XIII. p. 250.

Lit. Cl. Mr STEWART read the first part of his Biographical Account of the late ADAM SMITH, LL. D. [See Vol. III. Hist. p. 55.]

1793.

Jan. 7.

Dr Monro on the muscles, and on the effects of the oblique fibres.

Jan. 21.

Biographical account of Dr. Smith.

1793.
Mar. 18.
Biographical
account of Dr
Smith.

Lit. Cl. Mr STEWART read the remainder of the Biographical Account of the late ADAM SMITH, LL. D.

April 3.
Mr Playfair on
porisms.

Phys. Cl. Mr PLAYFAIR read some Observations on Porisms, additional to those formerly communicated. These were intended to prove, that the propositions called Porisms do not, as some mathematicians have alleged, involve in them any violation of the *law of continuity*. This subject belongs to the second part of the paper, No. VII. of the preceding volume; which second part has not yet been fully communicated to the Society.

Mr Fisher on
trigonometry.

At this meeting was also read a paper on Trigonometry, entitled, An Easy and General Method for solving all the Cases of Plane and Spherical Triangles, by the Reverend WALTER FISHER, minister at Cranstoun.

It has long been an object with mathematicians to reduce the rules of trigonometry to the ~~smallest~~ number possible, and to give them the form most easily retained in the memory. Lord NAPIER, whose discoveries have so much facilitated and abridged the labour of numerical calculation, applied himself to simplify the rules of trigonometry with great success. He invented the rule of the *Circular Parts*, which gives an apparent unity to theorems, where a real unity is wanting, and is perhaps the most fortunate attempt toward an *artificial memory* that has been made by any of the moderns.

VARIOUS improvements of this rule have since been proposed. That of M. PINGRÉ is one of the best: He retains Lord NAPIER's arrangement of the circular parts, and reduces the rules of spherical trigonometry to four; the two first of which are NAPIER's, and the other two a generalization of the common theorems respecting the segments, into which the perpendicular, drawn to any side of a spherical triangle, divides that side, and also the angle from which it is drawn. See

Mem.

Mem. Acad. Sciences, 1756, p. 301. There is a fifth rule, it must be observed, necessary for the case, when the three sides, or three angles of the triangle, are given, as this case refuses to submit to NAPIER's rule in any form of it.

THE author of the paper, now communicated to the Society, has also been successful in his attempt to render the rules of trigonometry easily retained in the memory. He employs the circular parts, and makes use of fewer rules than M. PINGRÉ, as he has only four, including one for the case just mentioned.

THE theorems Mr FISHER employs are not new, but they are judiciously selected, and are less embarrassing in the application than either those of NAPIER or PINGRÉ. They are as little as possible subject to ambiguity; they do not require the letting fall a perpendicular, and they apply both to plane and spherical triangles.

1. M denotes the *middle part* of the triangle, and must always be assumed betwixt two given parts. It is either a side or the supplement of an angle.

2. A and a are the two parts adjacent to the middle, and of a different denomination from it.

3. O and o denote the two parts opposite to the adjacent parts, and of the same denomination with the middle part.

4. l is the last or most distant part, and of a different denomination from the middle part.

THEOR.

THEOR. I.

$$\sin A : \sin a :: \sin O : \sin o.$$

THEOR. II.

$$\sin \frac{A-a}{2} : \sin \frac{A+a}{2} :: \tan \frac{O-o}{2} : \tan \frac{O+o}{2}.$$

THEOR. III.

$$\tan \frac{A-a}{2} : \tan \frac{A+a}{2} :: \tan \frac{O-o}{2} : \tan \frac{O+o}{2}.$$

THEOR. IV.

$$\sin A \times \sin a : 1 :: \sin \frac{A+a+1}{2} \times \sin \frac{A+a-1}{2} : \sin \frac{M^2}{2}.$$

MR FISHER recommends, for the purpose of remembering these rules, to commit to memory the words *Sao, Satom, Tao, Sarfalm*, formed from the abbreviation of the terms of the above proportions. It is obvious that these four theorems apply to plane triangles, providing that, instead of the sine or tangent of a side, you take the side itself.

1793.
Nov. 4.
Dr Hope on a
mineral from
Strontian.

Phys. Cl. Dr HOPE read a paper, giving an account of a Mineral from Strontian in Argyleshire, and of a Peculiar Species of Earth contained in it. A short abstract of this paper was inserted.

serted in the last volume of the Transactions. The paper itself is the first of the Physical Class in this volume. [See Part II. p. 1.]

Phys. Cl. Dr MONRO read a paper, being Experiments on the Nervous System with Opium and Metalline Substances, with a view of determining the Nature and Effects of Animal Electricity. This paper is published separately.

1793.
Dec. 2.
Dr Monro on
the nervous system.

At this meeting a paper was also communicated from ANDREW MACKAY, LL. D. containing an Account of a Series of Observations, made by him in the Observatory at Aberdeen, for determining the Latitude of that place.

Dr Mackay on
the latitude of
Aberdeen.

Dr MACKAY also promised to send his Observations for determining the Longitude of the Observatory. These were not received till September 1796. Both papers are inserted in this volume, Part II. No. VI. p. 135.

Dr JAMES ANDERSON read a paper, entitled, Observations on Peat Moss. This paper has been published separately.

1794.
Jan. 6.
Dr Anderson on
peat moss.

Phys. Cl. A paper was read from Mr LOCHEAD, F. R. S. Edin. on the Natural History of Guiana. It is inserted in this volume, Part II. No. II. p. 41.

March 3.
Mr Lochead on
the natural history of Guiana.

Phys. Cl. Dr HUTTON read the first part of a paper, being a Dissertation on the Philosophy of Light, Heat, and Fire. This paper, which consisted of several parts, was read at the different Meetings of the Society in May, June, July, August, and December, of this year. It has been since published separately in one volume 8vo. The following abstract contains an account of

April 7.
Dr Hutton on
the philosophy
of light, heat,
and fire.

of the object of the Dissertation, and of some of the reasonings employed in it.

DR HUTTON was led into the speculations contained in the Dissertation, by an account of two experiments made by M M. DE SAUSSURE and PICTET of Geneva. In the first of these experiments, two concave specula were placed opposite and parallel to one another, about twelve feet distant; and in the focus of one of them was a ball of iron, which had been heated to incandescence, but allowed to cool till it was no longer luminous, even in the dark. In the focus of the other speculum a thermometer was placed, which presently rose 8° (of REAUMUR's scale) above another that stood near it, but without the focus. *Voyages dans les Alpes*, tom. II. § 926.

To account for this phenomenon, M. DE SAUSSURE supposes, that there exists what M. LAMBERT and some other philosophers have called *radiant heat*, and that this heat may be obscure, and not accompanied with light. This radiant heat he conceives to be reflected in the same manner that light is, and by that means to have produced the effect on the thermometer that has just been described.

To this solution Dr HUTTON objects, alleging, that it ascribes properties or capacities to heat which are inconsistent altogether with our notions of it. We know heat only as a quality of bodies, and as acting either in expanding them, when it is called sensible heat, or in giving them fluidity, when it is termed latent heat. We never perceive it as existing in any other shape, and therefore, to suppose it capable of moving through space, independently of body, and of being reflected from a polished surface, is to ascribe to heat properties not predicable of it, and quite inconsistent with its nature, so far as we have information concerning it.

DR HUTTON therefore proposes another explanation. From experiments which he had made, long since, he had found that the

the different species of light, when of equal intensity, as estimated by the eye, are of unequal intensity when their effect is measured by the thermometer. In these experiments he rendered light of different colours equally intense to the eye, by increasing or diminishing the distance from the luminous body, till he could just read by the light of it. In this way he compared the red light from a fire of coals, with the white light of flame, and found, that while they were equally powerful in affording vision, the red was incomparably the most powerful in producing heat.

WHEN a body, therefore, is heated to incandescence, like the iron ball in M. DE SAUSSURE's experiment, it emits at first the white or compound light, but as it cools, the light which it emits becomes of the red species, and this is the last that disappears. As the body cools, therefore, the power of its light, to produce heat, increases in proportion to its power to afford vision, and, therefore, when this last vanishes, or ceases entirely, the other may still remain in a certain degree. Thus, in the experiment just described, the iron ball, after it had lost all light to the eye, continued to emit rays of light, which, though they made no impression on the organ of vision, had power to produce heat, and expand the mercury in the thermometer. To the principle, therefore, of the irradiation of obscure heat, by which M. DE SAUSSURE explains the above phenomenon, Dr HUTTON substitutes that of *obscure, or invisible light*, which, though it be in appearance more paradoxical, is in reality free from the very strong objections which press against the other hypothesis.

WE must not omit to observe, that M. PICTET varied the experiment, by placing a matrafs full of boiling water, instead of the iron ball, in the focus of one of the specula. The thermometer in the other was still affected, and raised a little more than a degree. The irradiation of invisible light explains this also; for it is natural to suppose, that such an irradiation takes place from

all bodies, when above a certain temperature, whether they be in the act of cooling down from incandescence or not.

THE same ingenious and accurate observer, made another change in the circumstances of the experiment, by smoking the bulb of the thermometer; in consequence of which it was heated sooner, and rose higher than before. This appearance is perfectly conformable to Dr HUTTON's theory, and seems quite inconsistent with the other. The black coating of the bulb, by its well known property of absorbing light, tended to accelerate and increase the effect of the light in heating the thermometer; but the same coating being of smoke, and a very bad conductor of heat, must have opposed the transmission of heat through the glass, and have both retarded and diminished its effect.

NOTHING, indeed, can be more unlike than the laws which usually regulate the propagation of light and heat. To move with extreme velocity through the transparent substance of some bodies; without heating them in any sensible degree; to be reflected from the surfaces of others, without entering them at all; and, lastly, to be absorbed by certain bodies, neither passing through them, nor being reflected from them, these are the properties of light. Heat, on the other hand, is slowly propagated through all bodies, combines with them intimately in its passage, and often remains at rest without any motion whatever.

THE conversion of these experiments, which was very ingeniously imagined by M. PICTET, led to a fact still more singular and unexpected. Instead of the heated body, he placed a matrafs, with ice in the focus of one of the specula; the consequence was, that the thermometer in the focus of the other was sensibly depressed. When the cold was increased, by pouring nitrous acid on the ice, the depression of the thermometer was also increased.

To account for this phenomenon, M. PICTET considers the thermometer as the body irradiating heat, and the matrafs with the ice as the body which receives it, so that the experiment is the same with the former, only that the obscure heat moves in the contrary direction.

THIS explanation, however, is not only liable to the objections that have been made, in general, to the supposition of radiant and obscure heat, but it involves in it new difficulties. It implies, for instance, that the irradiation from the heated body is affected by the state of the body which receives that irradiation, a principle surely contrary to all analogy. In the irradiation of light from a luminous body, nothing similar to this is observed: Whether the light of a candle fall on a white wall, by which it is reflected, or on a black wall, by which it is absorbed, no difference is produced in the quantity of light emitted, but it remains in both cases the same. In no case, it should seem, can the quantity of the radiating matter depend on the condition of the recipient bodies; yet, according to the preceding explanation, a body must be supposed to irradiate heat more copiously when the body on which the irradiation falls is cold than when it is hot; a supposition which, being, as has been said, contrary to analogy, cannot be admitted.

THE Doctor next proceeds to offer his own explanation, but with the diffidence that ought to accompany every attempt to account for a phenomenon so singular as this, and having so little analogy with any other fact that relates to the communication of heat. He supposes that all bodies irradiate invifible light, when they are of an ordinary temperature, and that this irradiation diminishes as their heat diminishes. The temperature of the thermometer, therefore, in the above experiment, is to be considered, like that of all other bodies, as being maintained by the action of two causes, viz. the irradiation of invifible light from the furrrounding bodies, and the communication of heat from

moderately

b 2

them

them by contact. The thermometer, therefore, that is placed in the focus of one of the mirrors, in the above experiment, will be affected by any body whatsoever that is placed in the focus of the other. If that body be cooled below the temperature of the surrounding bodies, less light will be irradiated from it, and reflected on the thermometer; the thermometer, therefore, will be depressed, till the influx of heat from the air, or other bodies with which it is in contact, supply the deficiency. This, however, is thrown out rather as a question to be resolved by future observations, than as a theory already established. The experiments by which it must stand or fall are not indeed difficult to be imagined. They are however of extreme delicacy in the performance; and Dr HUTTON, who, in differing from the philosophers of Geneva, does justice to the accuracy and judgment with which they have conducted their inquiries, expresses a wish, that the skill and ingenuity of M. PIC-TET were again directed toward this object.

By the preceding inquiry, Dr HUTTON was led to consider the connection between light and fire, as well as between light and heat; a subject which he had formerly treated of in several papers read before the Royal Society, and afterwards published in his chemical dissertations.

IN these he objected to the theory of fire as laid down by M. LAVOISIER, and the French chemists; acknowledging, at the same time, that the oxygenating of bodies, by vital air, is to be ranked among the greatest discoveries in physics. It is a discovery, however, in his opinion, that will by no means explain all the phenomena of burning, by which the existence of some other cause is clearly pointed out, beside the decomposition of the vital air, and the extrication of the *calorique* or *latent heat*, which maintained the air in a state of fluidity. The arguments in support of this assertion, which Dr HUTTON employs here, are founded on the appearances exhibited by bodies burning without

without flame, and burning with flame; that is, on the phenomena of combustion and inflammation.

In the combustion of a piece of charcoal, two distinct effects may be traced, viz. 1. The oxygenating of the carbonic substance, by which fixed air is produced, or carbonic acid in an elastic state; 2. The production of a great quantity of light and heat, while the charcoal is undergoing this change. It is with respect to this last part of the process only that different opinions are entertained. The phlogistic theory maintains, that in the oxygenation of the carbonic substance by the vital air, the phlogistic matter of that substance is set free from combination with it, and in making its escape exhibits the phenomena of light and heat.

The antiphlogistic theory, on the other hand, supposes, that, by the decomposition or the condensation which the vital air undergoes, while it oxygenates the carbonic substance, the latent heat is transferred to that substance, and produces light and fire.

Now, if it can be shewn that a burning coal, though placed in circumstances the most favourable for its oxygenation, may nevertheless lose its heat, and cease to burn entirely, it is certain, that it is not alone by the *calorique* of the vital air that the fire is supported. Let then a consolidated piece of charcoal, such as the mineral kingdom, in many places, affords in great perfection, be heated to the highest degree of incandescence, and exposed, insulated, to the atmospheric air. Here every condition is united favourable to the oxygenation of the coal, a sufficient quantity of heat, and free access of air. If the heat, supplied from the decomposition of the vital air, were able to maintain the heat of the coal, it would continue to burn; but the fact is, that, in such a situation as is here described, the coal loses its heat, and it is at last extinguished. It is plain, therefore,

fore, that more heat is lost by communication with the atmosphere than is acquired from the decomposition of the vital air.

Now, let the experiment be so far varied, that the incandescent coal, instead of being suspended singly in the atmosphere, is surrounded with other burning coals, that are likewise suspended, and at such a distance from it as to leave room for the free passage of a current of air: We know, with certainty, that the central coal will now continue to burn as long as those that surround it are incandescent, or emit a certain degree of light. But the circumstances of the coal, in this experiment, are in nothing more favourable to the receiving of heat from the decomposition of the vital air than they were in the former; for if it be said, that the air ascends through the greater mass of burning matter, with more rapidity than before, and so deposits more of the *calorique*, it must be remembered, that it also abstracts more heat from the coals, just in the same proportion, or in proportion to its rapidity. If then the antiphlogistic theory be true, the heat acquired by the coal, in the one of these experiments, should be to the heat abstracted from it, in the same ratio that the heat, acquired in the other experiment, is to the heat abstracted. But this does not hold; for the heat acquired, in the first experiment, is less than the heat abstracted, and in the second it is not less, but is either equal, or greater. Therefore the antiphlogistic theory is not true; that is to say, the theory which derives the supply of heat, in burning bodies, entirely from the *calorique* of the vital air.

WE must therefore admit another cause, before we can fully explain combustion; and this can be no other than the extrication of the phlogistic matter of the body which is oxygenated, the conversion of that matter into light, and then the production of heat.

IN the phenomena of inflammation, Dr HUTTON thinks that the proofs of his theory of fire are no less conclusive than in those

those of combustion. The inconceivable rapidity with which fire is propagated through an inflammable and transparent vapour, is among the most remarkable of those phenomena, and is certainly inconsistent with the new theory of burning, and indeed with every other that makes fire to be produced by heat alone. Let an inflammable fluid be heated till it boil, and to the top of the column of vapour emitted from it let the smallest spark of flame be applied. The vapour is kindled, and, however high the column, the flame descends in an instant to the surface of the inflammable substance, and sets fire to it. Now, it is impossible that mere heat could descend in this manner, against the stream of vapour that is continually rising from the boiling fluid. This is quite contrary to the laws by which it is usually propagated; and it should seem, that the fact can only be accounted for by the celerity with which light moves through transparent bodies, and by supposing that the extrication of light is the immediate cause of burning.

THE above instance is conformable to the experience of every day: Another example, which Dr HUTTON gives of the celerity with which fire is propagated through an inflammable and transparent vapour, is more singular, and may perhaps be thought hypothetical, but it is at least a very happy application of his theory. This example is the meteor, which was seen in 1783, over all Great Britain, and as far south as Paris. There can be no doubt, says he, that this was a stream of inflammable vapour which had issued from the mineral regions of Iceland; at that time laid waste by subterraneous eruptions. This train of inflammable vapour, about 60 miles high in the atmosphere, had been kindled at the north end, probably by an electrical spark, and the inflammation ran the space of several hundred miles, (at least 1000), in a minute of time, or little more.

Thus the inflammation of a body of pure vapour, in contact with the atmospheric air, is made with a rapidity quite inconsistent

sistent with the propagation of heat. Instances, still more remarkable, of the rapid progress of fire, are found in the inflammation of such vapours, when mixed with that proportion of vital air which is necessary for decomposing the phlogistic substance.

ON the whole, Dr HUTTON concludes, that in no case is the light which appears in burning, an effect of the heat obtained from the decomposition of vital air, but that it is the extrication of phlogiston, of fixed light, or a certain modification of the solar substance, which had existed in the inflammable bodies, and had been chemically combined with their elements. It appears also, that it is light which is immediately produced in burning, and that it is only mediately that heat is excited: This is true both of combustible bodies which burn in an associated state, and of those inflammable substances where the emerging light heats both the inflammable body, and the contiguous atmospheric fluid.

THE Doctor proceeds to explain, more at large, his notions of the solar substance, of which he conceives light, heat, phlogiston, and electricity, to be so many different modifications. His notions on this subject are very peculiar, as he conceives the solar matter to be without gravitation, without inertia, and, it may be added, without extension. The nature of this abstract does not admit of entering further on the argument: It is sufficient to remark, that the theory of *heat* seems to be arrived at a point where it must almost unavoidably stand still, till some experiments shall determine how far the gravitation of bodies is affected by the heat, whether sensible or latent, that is contained in them. The experiments already made, though ingeniously contrived, and ably executed, are not sufficient to decide a question of such extreme delicacy; nor does it seem probable, that, without having recourse to the pendulum, a satisfactory solution of the difficulty will ever be obtained.

Phys. Cl. Dr MONRO read a paper, concerning the Communication of the Ventricles of the Brain with one another, in Man and Quadrupeds. This paper is published in Dr MONRO's book, entitled, *Three Treatises, &c.*

1794.
Aug. 18.
Dr Monro on
the communica-
tion of the ven-
tricles of the
brain.

MR KEITH also communicated an Improvement of the Mercurial Level, described in the Second Volume of the Transactions of the Society.

Mr Keith on an
improvement of
the mercurial
level.

THIS improvement consists in a contrivance for avoiding the trouble of pouring the mercury out and into the level, every time it is used. Beside the canal of communication at the bottom, between the two upright columns of mercury, on which the *floats* swim, (see Vol. II. Part II. No. III.), there is, in the new construction of the instrument, another canal, parallel to the former, cut in the upper part of the wood, which allows the air to circulate freely, according as the mercury below rises or falls. The whole is made perfectly close, so that no air can get admittance.

THE instrument may be carried about in this manner, with the mercury remaining in it; and though by agitation that fluid calcines, and is converted into a grey powder, this only happens when it has free access to vital air; and as all such access is here prevented, the mercury will not lose its metallic lustre.

THE level, in this form of it, as it requires no previous adjustment, is very commodious, and, when much accuracy is not required, may be used with advantage.

Phys. Cl. Dr ANDERSON read a paper, entitled, *Observations on Wool-bearing Animals.*

1795.
Jan. 5.
Dr Anderson
on wool-bearing
animals.

Phys. Cl. Mr PLAYFAIR communicated an Abstract of a Journal of the Weather, kept at his House in Windmill Street,
VOL. IV. c for

Feb. 2.
Mr Playfair on
the weather of
1794.

for the year 1794. This abstract, with those for 1795 and 1796, make the last of the Physical papers in this volume.

1795.
Feb. 2.
Dr Anderson on
the making of
indigo.

At this meeting Dr ANDERSON also read a paper on the Making of Indigo at Tranquebar, by Dr ANDERSON of Madras.

Extract of a
letter from
W. Hall, Esq;

AN extract of a letter from W. HALL, Esq; of Whitehall, Berwickshire, was read, giving an Account of a Great Degree of Cold which he had observed on the Evening of the 22d of January, when the Thermometer stood between 5 and 6 degrees below 0 of FAHRENHEIT's scale.

March 2.
Dr Wilson on
the effects of
opium on the
living animal.

Phys. Cl. Dr ALEXANDER WILSON read the first part of a paper, concerning the Effects of Opium on the Living Animal. This paper has been published separately: An abstract of it follows.

THE difference in the results of the experiments that have been made to ascertain the effects of opium, and the inconsistency of the conclusions deduced from them, led Dr WILSON to enter on the experimental investigation contained in this paper. The first point which he endeavours to ascertain is, whether opium, applied to the internal surface of the heart, is capable of so affecting its nerves, as to act on those of every part of the body, producing the general convulsions observed on injecting a solution of this drug into the heart or blood-vessels. It appears from his experiments, that the only effects of the application of opium to the internal surface of the heart, are those of interrupting its motion, and destroying its irritability; and that when convulsions succeed, they are owing to the opium being conveyed along the aorta, and immediately applied to the brain. It has also been asserted, that opium, applied to distant parts of the body, is capable of affecting the motion of the heart, through the medium of the nervous system. Injected into the cavity of the

the abdomen, for instance, it almost immediately impairs the action of the heart. It is only, however, when applied to an extensive surface that it has this effect; and if Dr WILSON's observations be just, this effect is not produced through the medium of the nervous system; but is the consequence of the opium destroying the muscular power, and, consequently, the circulation in those vessels to which it is applied; thus suddenly diminishing the supply of blood to the heart, and at the same time opposing an additional obstacle to its perfect evacuation. The experiments, next related, demonstrate that opium, immediately applied to the brain itself, although it excites violent and universal convulsions in all the muscles of voluntary motion, is incapable of affecting at all the contractions of the heart. It even appears, from these experiments, that although opium be applied at the same time to the brain and spinal marrow of a frog, in consequence of which, (if the solution employed be strong), the animal instantly expires, as if thunderstruck, the motion of the heart is not in the least affected by it. It continues to beat with the same frequency and force after, as it did before, the application of the opium. We arrive, then, at this conclusion, that opium, applied to a distant part of the body, does not affect the motion of the heart, through the medium of the nervous system; nor, on the other hand, does opium, applied to the heart, affect any other part of the body, through the same medium. But the heart is not the only muscle, which opium, applied to a distant part, seems incapable of affecting through this medium. Many considerations render it highly probable, that the same is true of all the muscles of involuntary motion, without exception. That it is so of the muscular coat of the alimentary canal, which, next to the heart, may be considered the chief of this class of muscles, appears from the experiments next related. On comparing the experiments above alluded to, with those in which opium thrown into the stomach

and intestines, the cavity of the abdomen, &c. is found to produce convulsions, it appears probable, that in the latter cases, as in the former, the convulsions do not proceed from any action of the opium on the nerves of the part to which we apply it, but from its being received into the sanguiferous system, and immediately applied to the brain. The experiments which follow, in the treatise, confirm this conjecture. On comparing together all the experiments there related, and those alluded to in the introduction, it appears, that the various effects of opium on living animals may be divided into three classes. The first comprehending its action on the nerves of the part to which it is applied, not differing essentially from that of any other local irritation. The second comprehending its effects on the heart and blood-vessels; that of increasing their action, when applied in a small quantity; and that of impairing, or altogether destroying their power of action, when applied to them more freely. The third comprehending its effects, when immediately applied to the brain; which, when the dose is moderate, are impaired sensibility, languor, sleep; when applied more fully, convulsions and death. In all its effects on the living animal body, opium has much, in common with other substances, but at the same time something in each peculiar to itself. It may appear an omission, Dr WILSON observes, that he has not ranked among the effects of opium, received into the system, those which it seems to produce on the muscles of voluntary motion. In some of the foregoing experiments, the irritability of these muscles was found much impaired after death, although the opium was not applied directly to the muscles themselves. But it appears, both from an experiment related in the Treatise, and others alluded to, that the impaired irritability of these muscles is owing, not to any direct action of the opium on them, but to the violent convulsions excited in them, in consequence of the opium being applied to the brain.

THE

THE doctrine of the sympathy of the nerves has been so much employed in accounting for the effects of opium, that Dr WILSON judged it proper to make some observations upon it; in which he endeavours to prove, that no such law of the animal œconomy exists; and that all the phenomena, which have been referred to this supposed law, depend on certain changes taking place in the *sensorium commune*.

IN an appendix, he relates some experiments, made with a view to determine the manner in which tobacco acts on living animals. From these experiments it appears, that the symptoms which tobacco produces, when thrown into the heart, are the same with those excited by its immediate application to the brain. That these symptoms, when the tobacco is exhibited in the former way, proceed from no action of the tobacco on the nerves of the heart, but from its being conveyed along the aorta, and immediately applied to the brain; since they do not follow its injection into the heart, when the aorta is previously secured by ligature; although it was found, that interrupting the circulation does not unfit the nervous system from undergoing the change necessary for the production of such symptoms. It also appears from these experiments, that tobacco produces the same effects, though more slowly, when thrown into the stomach and intestines as when thrown into the heart: That in the former case, as in the latter, they are still to be ascribed to the tobacco being received into the sanguiferous system, and immediately applied to the brain; and that the effects of this drug, when it acts merely on the nerves of the part to which it is applied, do not essentially differ from those of any strong topical irritation. It may also be collected from these experiments, that the presence of tobacco in the system, like that of opium, only affects the irritability of the muscles of voluntary motion, when it produces convulsions in them; *i. e.* when it is applied in considerable

able quantity to the brain. It appears, therefore, that the *modus operandi* of tobacco, on the living animal body, is in every instance analogous to that of opium.

1795.
April 6.
Mr Playfair on
the trigonome-
try of the Brah-
mins.

Phyf. Cl. Mr PLAYFAIR read a paper on the Trigonometry of the Brahmins. The paper is inserted in this volume, Part II. No. IV. p. 83.

May 5.
Mr Wilson on
motions of
wicks in a ba-
son of oil.

Phyf. Cl. Mr PLAYFAIR communicated a letter from Mr Professor WILSON of Glasgow, giving an Account of certain Motions observed in small lighted Wicks, when made to swim on a Bason of Oil, or any other Fluid which can maintain Flame. [See this volume, Part II. No. VI. p. 163.]

June 1.
Dr Wilson on
the effects of
opium on the
living animal.

Phyf. Cl. Dr ALEXANDER WILSON read the remaining part of his paper on the Effects of Opium on the Living Animal.

Dr Anderson on
making chinam.

Dr JAMES ANDERSON also read an Account of the Method of making Chinam at Madras, communicated by Dr ANDERSON of Madras.

June 15.
Mr Marshall on
the Argonautic
expedition.

Lit. Cl. Mr DALZEL read an Essay on the Argonautic Expedition, by the Reverend Mr EBENEZER MARSHALL, Minister at Cockpen.

Aug. 3.
Mr Keith on
different ther-
mometers.

Phyf. Cl. Mr KEITH read a Description of different Thermometers, accompanied with figures, by which the Degree of Heat may be recorded for every hour and minute throughout the year.

Nov. 2.
Dr Monro on
the internal hy-
drocephalus.

Phyf. Cl. Dr MONRO read a paper on the Internal Hydrocephalus. This, with some other papers, already mentioned, by the same Author, have been published separately; and as an account of the

the discoveries, which Dr MONRO has made in the Structure of the Brain, the Ear, &c. could not be sufficiently understood without the numerous plates by which they are illustrated, it is unnecessary to attempt any detail of their contents.

Phys. Cl. A paper, by Dr BALFOUR of Calcutta, was communicated, on the Diurnal Variations of the Barometer.

DR BALFOUR's Observations, on the Diurnal Variations of the Barometer, were made at Calcutta, and communicated to the Asiatic Society in 1794. A copy of them, which he sent to a friend in Edinburgh, was the paper now read in the Royal Society.

THE situation in which these observations were made, entitles them to peculiar attention; for it is well known, that, between and near the tropics, the barometer is very steady, and free from those great and sudden changes that take place in higher latitudes. It is in such situations, therefore, that the smaller periodical variations of the barometer, if they exist at all, are likely to be discovered, as being separate from those accidental irregularities with which they must be complicated in our northern climates.

DR BALFOUR's diligence, in observing the barometer, has also been singularly great. He imposed on himself the task of observing the state of that instrument every half hour, for an entire lunation, from the new moon on the 31st of March, to that of the 29th of April 1794.

THE result was, the discovery of a periodical variation in the barometer, consisting of two oscillations, which it performs regularly every twenty-four hours.

I. ON every day, that Dr BALFOUR observed, with scarce any exception, the barometer constantly fell between ten at night

1796.
Jan. 4,
Dr Balfour on
the diurnal va-
riations of the
barometer.

night and six in the morning; and this it did progressively, without any intermediate rising but in one instance.

2. BETWEEN six and ten in the morning the barometer constantly rose; it also did so progressively, and rarely with any intermediate falling.

3. BETWEEN ten in the morning and six at night the barometer fell progressively, without a single exception.

4. LASTLY, between six and ten at night the barometer rose progressively, without any intermediate falling, except in one instance.

THESE are Dr BALFOUR's general conclusions; and, accordingly, on casting an eye over the table into which he has reduced his observations, one is immediately struck with the appearance of two *maxima*, viz. at ten at night and ten in the morning; and, again, two *minima*, also diametrically opposite to one another, at six in the morning and six at night.

THE quantity of these diurnal variations is not very considerable, but sufficient, at the same time, to leave no doubt of their reality. The difference between the contiguous *maximum* and *minimum* is sometimes $\frac{1}{16}$ of an inch, though in general it is less than half that quantity.

It does not appear that the above variations have any relation to the heat and cold of the atmosphere, or to the changes of the temperature of the mercury in the barometer, though, with respect to this last, we are not furnished with sufficient information.

TILL these observations are further multiplied and extended, it will be in vain to attempt any explanation of the facts to which they relate. It seems not improbable, however, that they are connected with the reciprocations of the sea and land winds, during the day and night, or with the heating and cooling of the superincumbent atmosphere. It would be of great use to have

have the observations repeated at different seasons of the year. An observer equally assiduous with Dr BALFOUR will not be easily found; but it will perhaps be sufficient to observe the barometer every three hours, and particularly at the stationary points.

IT is proper to remark here, that some observations of a similar sort have been made in Europe; where, though the situation is far less favourable, than in India, for discovering the true law of such minute variations, results have been obtained tolerably consistent with one another, yet differing considerably from those that are stated above.

A SERIES of such observations was instituted by M. PLANER of Erfort in Germany, and is described in the *Ephemerides* of the Meteorological Society at Manheim for 1783. Before these observations, it had been remarked, that when the barometer is rising, it stands lower at noon than at any other time of the day, and higher at the same hour when it is descending. M. PLANER's observations seem to extend and modify this conclusion; for they make it appear, that between ten and two, both of the day and night, that is, for two hours before, and two hours after the sun is on the meridian, the elevations and depressions of the mercury are less than at any other time of the day; and that between six and ten in the morning, and, again, between six and ten at night, these elevations and depressions are the greatest. The same rule seems to be confirmed by the observations of M. COTTE in France, of which he has given an account in the *Journal de Physique* for 1792 and 1794.

THESE last conclusions seem to indicate some periodical retardation of the movement of the mercury in the barometer, whether ascending or descending; but it is difficult to form any notion of the force by which such an effect can be produced. Perhaps the only general inference that is yet deducible, from comparing all the circumstances, is, that certain diurnal va-

riations of the barometer do actually exist; that more information on the subject is necessary before any explanation of them can be attempted; and that it is in the countries lying near to the equator that we are to look for these periodical variations least interrupted and obscured by accidental irregularities.

1796.
Feb. 1.
Mr Playfair on
the weather of
1795.

Phys. Cl. Mr PLAYFAIR read an Account of the Weather for 1795, extracted from his Journal kept for the Society.

Feb. 15.
Biographical
account of Lord
Abercromby.

Lit. Cl. Mr MACKENZIE read his Biographical Account of Lord ABERCROMBY. [See History of the Society, Appendix, p. (1)].

March 7.
Mr Wallace on
geometrical por-
isms.

Phys. Cl. A paper was communicated, containing Certain Geometrical Porisms, with their Application to the Solution of Problems, by Mr WILLIAM WALLACE, Assistant-teacher of the Mathematics in the Academy of Perth. [See this volume, Part II. No. V. p. 107.]

March 21.
Biographical
account of Dr
Robertson.

Lit. Cl. Mr STEWART read the first part of his Biographical Account of the late Dr ROBERTSON.

April 4.
Biographical
account of Dr
Roebuck.

Phys. Cl. A Biographical Account of the late Dr ROEBUCK was read, communicated by Mr Professor JARDINE of the University of Glasgow. [See Hist. Appen. No. IV. p. (65)].

May 2.
Extract of a
letter from
W. Hall, Esq;

Phys. Cl. An Extract of a Letter from Mr HALL to Sir JAMES HALL, Bart. was read, giving an Account of an Extraordinary Halo of the Moon, observed on the 18th of February last. [See this Volume, Part II. No. VII. p. 173.]

Phys.

Phys. Cl. Mr STEWART read a paper by Dr HUTTON, viz. An Examination of a New Phenomenon which occurs in the sulphurating of Metals, with an Attempt to explain that Phenomenon.

AN account that was given, some time ago, in the Literary Journals, of certain experiments made in Holland on the sulphurating of metals, gave rise to this communication. According to that account, when metallic filings are mixed with sulphur, and exposed in a close vessel to a certain degree of heat, the mass kindles, and burns not only without vital air, but in any air whatsoever, or even in a vacuum. In the experiment, as thus represented, Dr HUTTON readily saw a strong argument against the theory which explains the phenomena of fire by the extrication of the *calorique* of vital air; and in this light he considered it in the end of the Dissertation on the Philosophy of Light, &c. of which an abstract has been already given. Dr HOPKINS having however suggested to him, that, in making the experiment, he had seen reason to doubt the reality of the inflammation, they agreed to repeat the experiments together. Dr HUTTON was then convinced that this fact had been misrepresented, or rather misunderstood; and therefore thought it necessary, in this paper, to correct the error into which he had been led by that misrepresentation, describing the real appearances, and endeavouring to explain them on known principles. "In doing this," says he, "I shall destroy the argument which the experiment seemed to afford against the doctrine of *calorique*, but I shall have no reason to change the conclusion that I formed against that doctrine, founded on facts that are universally acknowledged."

THE fact, as these gentleman observed it, is this: The metal and sulphur being mixed in due proportions, and exposed to heat in a close glass vessel, the sulphur first melts, then undergoes a kind of ebullition, emitting vapours which condense in the upper part of the vessel, and are a sublimation of the sulphur. In

1796.
May 9.
Dr Hutton on
the sulphura-
ting of metals.

this state, and while the heat communicated was still under that of incandescence, there appeared in the bottom, or hottest part of the mass, an incandescent spot, which increased in size. The glass vessel was now removed from the fire, and carried into a dark room, that the light emitted from it might be the more accurately observed. There the incandescence was plainly perceived, spreading from the place where it first began, and gaining ground continually, till the whole became very luminous. The heat, when thus diffused through the mass, begins instantly to diminish, and the body quickly cools, as a similar mass of any other substance would do. These are the appearances observed in the experiment; and are what Dr HUTTON proceeds to explain.

It is evident that the incandescence, which has just been described, is an operation proceeding from the mass itself, and not from the intensity of the heat communicated to it, for that heat is not sensibly incandescent; whereas the heat which the mass acquires, after the vessel is removed from the fire, is considerably luminous. We have here, therefore, a species of kindling like that of burning bodies; but, at the same time, distinctly different from it. In burning, a phlogistic substance is decomposed, by means of the oxygenating principle; and the matter of light, which was contained in that substance, being set at liberty, is emitted in the form of light, and heats those bodies by which it happens to be extinguished or absorbed. But, in this experiment, though the mass is a phlogistic substance, there is no decomposition of the phlogiston, no appearance of inflammation; so that its incandescence proceeds from another cause than that which operates in burning. On attending to the circumstances, however, we shall perhaps discover that the phenomena of this experiment are not anomalous, but follow a rule, exemplified in many instances, though not precisely with the same appearances.

THIS

THIS rule seems to be no other than that which regulates the extrication of latent heat, when bodies pass from a fluid to a solid state, though this case is somewhat more complicated than usual, and attended with circumstances that are yet but imperfectly understood. It must therefore be considered, whether the sources of latent heat in the bodies, here combined, be such as we can reasonably suppose adequate to the effect produced.

FIRST, then, we have the latent heat of the sulphur, when it is simply in its melted state; it has then an aqueous or perfect fluidity, to which the quantity of its latent heat necessarily corresponds. But this is not precisely the state in which the sulphur combines with the metal; for before that happens, and while the sensible heat increases, the sulphur becomes viscid, and loses its perfect fluidity. We have nothing with which we can compare this phenomenon, or by which we can estimate the latent heat now contained in the sulphur. There is however reason to think, that this heat is of the species which Dr HUTTON, in his Differtations on subjects in Natural Philosophy, distinguishes by the name of the *latent heat of ductility*. The reason for this supposition is, that when the sulphur, in its viscid state, is plunged into cold water, it does not concrete into its usual, hard, friable, and crystallized structure, but is changed into a transparent ductile mass. This state it seems to owe to the latent heat contained in it; for after some hours exposure to cold, it gradually loses its ductility, and undergoes another change of structure, so as to resume its ordinary appearance, as if it had been concreted and crystallized from the state of simple fluidity.

BUT the sulphur also emits another species of heat, on its combination with the metallic substance. This is what may be called the constitutional heat of a body, or that by which its volume is preserved in opposition to any force endeavouring to diminish

diminish it. The volume of the sulphur is obviously much diminished on its combination with the metal ; and therefore a quantity of its *constitutional heat* must be expelled, corresponding to the condensation or diminution of bulk which it has undergone. This quantity may be very great ; but it is what at present our science has not the proper means of estimating.

SUCH are the sources of heat contained in the sulphur. The metal also, by losing its ductility, may emit a certain quantity of latent heat, and may thus contribute to increase the sensible heat of the compound mass. The quantity of this effect, like the former, it is difficult to estimate.

THESE, then, are the different species of latent heat, which may be supposed to emerge, and become sensible, on the combination of the sulphur and the metal in the preceding experiment, and on the instantaneous concretion of the compound mass. The consequence of this must be, that the mass already heated, from without, nearly to a red heat, having this additional heat communicated, must become incandescent, and emit light. This must happen, even if the latent heat emerging should be but in a very small quantity ; and thus the leading fact of the incandescence seems to be sufficiently accounted for.

IT may also be useful to remark, that there are other cases in which incandescence seems to be produced, on the principle here assigned, though not perhaps in a degree equally remarkable.

IN the assaying of silver on the test, when the lead is sufficiently separated, so as to leave the silver still fluid, but in a degree of heat inferior to what is required to melt it, or to preserve its fluidity, the button of silver instantly concretes, and appears at the same time much more luminous. Here there is evidently no cause that operates, but the latent heat of fluidity, emitted, as on all occasions, when concretion takes place ;

place; and had the silver been here, in the lowest degree of incandescence, or the highest degree of obscure heat, the phenomenon would have been as remarkable as in the sulphurating of metals.

ON the same principle it seems to be, that, in a very common, but very instructive experiment, a bar of cold iron is made incandescent, by hammering it with a certain degree of rapidity and force, so that the condensation may be sufficiently quick to expel the heat all at the same time, or nearly so. In this case, it is the latent heat of ductility that is made to appear, as in the congelation of water it is the latent heat of fluidity.

IRON also furnishes another example of the same kind, where the incandescence is very conspicuous, but where the process is not so simple as in the former instances, because a part of the light is probably produced from another cause. This example is found in the conversion of pig iron into malleable iron by Mr CORTE's process, viz. by keeping the iron melted in a reverberatory furnace, and exposed, by being agitated, to the influence of the atmosphere. When the cast iron comes in this manner to its malleable state, it quickly displays the brightest incandescence possible, coagulating, at the same time, from its melted state. Now, there can be no doubt that this extreme incandescence arises from the commutation of latent into sensible heat, and the commutation of that heat again into light, in which state it is emitted by the incandescent body. In this case, however, it is probable, that there is also light emitted immediately on the principle of burning, and that the iron is in part scorified, by being oxygenated and losing its phlogiston. But this also is in a great measure owing to the extreme heat produced by the congelation of the iron; for the heat of melted iron is not alone sufficient for that effect.

THE theory above laid down will enable us to explain all the different steps in the complicated process of the sulphurating
of

of metals. When the mixture of the metal and sulphur is exposed to heat, and the sulphur melted, it is not immediately combined with the metal; for it requires a greater degree of heat, and one which is perhaps nearly that of incipient incandescence, to produce the compound substance of the sulphurated metal. The moment, however, that this combination is formed, that part of the mass, in which it began, loses its fluidity, and is made to concrete, and at the same time becomes strongly incandescent. In this state, if the glass vessel be removed from the fire, the process of the combination of the sulphur with the metal will be carried on, as has been described above. For the first incandescent part is that which had been most immediately exposed to the heat of the burning coals, and had, by that means, acquired the temperature necessary for the combination of the two substances; but at this time the part immediately contiguous to the concreted portion of the mass is in the next degree of heat; consequently, upon the emerging of the latent heat of the first portion, this second portion, having its heat increased, is made to combine, and, by its instant consolidation, produces incandescence. This incandescence of the second portion produces a like effect upon the third; and thus the heat, combination, concretion, and incandescence, spread quickly through the whole mass, without any further assistance from external fire.

IN all this there is so great a resemblance to the phenomena of burning, that some attention is necessary to enable an observer to distinguish the one process from the other.

WHEN a mass of charcoal, properly prepared for combustion, is kindled in one part by the heat of incandescence, the oxygenation begins, attended with the decomposition of phlogiston, and the emission of the fixed light. The neighbouring parts being then heated, by the light emitted from the first kindled part, are also kindled themselves, and serve to augment both the

the intensity of the heat and the extent of the burning. In this manner the parts of the mass are kindled in succession, until the whole is incandescent; it is at the same time gradually consumed, the vital air uniting with the carbonic principle, and this last being deserted by the fixed light of the phlogiston.

IN the sulphurated mass, though there be the same appearance of ignition propagated successively from a central point to the adjacent parts, yet it is not real ignition, but simple incandescence, produced from the extrication of latent heat, in the manner already explained. It is distinguished from ignition by this circumstance: that, as soon as the incandescence has spread over the whole mass, there is an end of the generation of heat, and the sulphurated metal cools from its incandescent state, like any other incombustible body heated to the same degree. In the whole process there is no oxygenation; no production of fixed or carbonic air; no apparent waste; nor any thing emitted from the mass, except the light of incandescence.

THUS, Dr HUTTON concludes, that, in the process of the sulphurating of metals, we perceive the action of the same laws as in the conversion of water into ice, and must explain both on the great principle, by the discovery of which his friend Dr BLACK rendered so important a service, not to chemistry alone, but to many other branches of natural philosophy.

HE is aware, however, that an explanation of it will also be attempted by some chemists, on the principle of the change of the capacity for heat; an explanation which he considers as extremely fallacious and unphilosophical. When he applies these epithets to the doctrine of the capacities for heat, he does not mean to object to the phrase, *capacity for heat*, or to the application of that phrase to express a mere matter of fact, viz. the difference of the specific heat of bodies, or the unequal quantities of heat contained in different substances, when their

masses and temperatures are equal. But what Dr HUTTON calls fallacious and unphilosophical is, the assigning the change in the capacity of a body for heat, as the cause of the absorption or emission of heat, at the moment when that change takes place. This supposition is grounded, as he contends, on a false view of the facts concerning the transition of water from a hard to a fluid state, or the contrary. The chemists, for example, who maintain this doctrine, hold, that when water is cooled down to a certain temperature, it necessarily freezes and becomes ice, a substance that has a much less capacity for heat than water has; on which account a certain quantity of the heat contained in the water is expelled, and enters into the surrounding bodies. Now in all this it is supposed, that water, at a certain temperature, is necessarily changed into ice, which is by no means true; because it is well-known, that water may be cooled several degrees below what is called the point of congelation without losing its fluidity. Dr HUTTON tells us, that he has found means to cool it no less than 30° below that temperature, without its being changed into ice. Though it be true, therefore, that water must be cooled to a certain temperature before it can freeze, it is not true, conversely, that it does freeze whenever it is cooled to that temperature. It follows, as a necessary consequence, that something else beside a change of temperature is essential to congelation, and is the cause of that wonderful change which water undergoes in passing from a fluid to a solid state. The separation of the latent heat seems a cause more adequate to the effect, and serves to explain the cooling of the water below the point of congelation, without the loss of its fluidity, because this only happens when the escape of the latent heat is prevented.

THAT the heat, absorbed by the water, is the true cause of its fluidity, appears from the facility with which this hypothesis explains

explains all the other phenomena of congelation. There is, as has just been said, a certain fixed temperature, at which water and ice are convertible into one another. At this temperature, however, a mixed body of ice and water may remain for ever without any of the water being congealed, or any of the ice melted; but let there be added to this compound mass a quantity of heat, by communication from a warm body, and there is a certain quantity of the ice melted, while the mass remains in its former temperature. Now, if we measure the quantity of the heat, communicated to this compound mass, without changing its temperature, and also the quantity of ice melted, that is, the quantity of fluidity produced, it will be found that they are in all cases proportional to one another, and have therefore the relation of cause and effect. This certainly amounts to no less than a full demonstration, that the heat absorbed, or rendered insensible to the thermometer, is the cause of fluidity. To say, that the change of the capacity for heat is the cause of the absorption of the heat, is, in fact, to affirm, that the fluidity of the water is the cause of that absorption, and, of consequence, leaves the fluidity as a phenomenon without a cause: for it has been shown that mere change of temperature is not the cause of it.

DR HUTTON has been remarkably happy in his explanation of the manner in which heat produces fluidity. Heat, says he, has two distinct effects on body: The one of these consists in its power of distending the substance of the body, or increasing its volume, and this is the effect that is measured directly by the thermometer: The other effect of heat is to move the particles of hard bodies on their *axes*, and by this rotatory motion to separate their poles of attraction, which were united in their state of hardness and solidity. The particles of the body, in consequence of this rotatory motion, are in a state

of equilibrium; they have no disposition to cohere together, and are ready to obey the impression of the smallest force.

SUCH are the ideas which Dr HURTON had formed on the sulphuration of metals, and the theory by which it must be explained; and they are rendered more interesting, by being the last communication made by that ingenious and profound philosopher.

1796.

June 20.
Biographical
account of W.
Tytler, Esq;

Lit. Cl. Mr MACKENZIE read a Biographical Account of the late WILLIAM TYTLER, Esq; of Woodhouselee. [History, No. II. p. (17)].

July 4.
Dr Walker's
statistical ac-
count of Col-
lington.

Phys. Cl. Some Passages from Dr WALKER's Statistical Account of the parish of Collington were read.

Nov. 7.
Mr Ivory on
the rectification
of the ellipsis.

Phys. Cl. Mr PLAYFAIR communicated an Extract of a Letter from JAMES IVORY, A. M. containing a New Series for the Rectification of the Ellipsis. [See Part II. of this volume, No. VIII. p. 177.]

Dr Mackay's
determination of
the longitude of
the Observatory
at Aberdeen.

AT this Meeting Dr MACKAY's Determination of the Longitude of the Observatory at Aberdeen was also communicated. [Part II. of this volume, No. V. p. 140.]

THE establishment of a New Observatory, where there are so few as in Scotland, is an event of too much importance, in the literary history of the country, to be passed over without notice. The establishment of that at Aberdeen ought the more to be recorded, that it does great honour to the public spirit and scientific zeal of the Principal and Professors of the Marishall College, and of the other gentlemen by whose voluntary subscription it was brought about. From the funds which their subscription afforded, an Observatory was built in 1781, on a part of the Castle Hill, which was given in a present to the College

College by the Magistrates and Town-Council of Aberdeen. The building consisted of three rooms, two of which, forming the wings, were circular, about 12 feet in diameter, with conical roofs. The eastermost of these was for the quadrant, and had its roof moveable, and furnished with flits; the western was the transit room; its roof had flits, but was not moveable; the room in the middle served for the accommodation of the astronomer.

THE instruments, with which the Observatory was furnished, were a transit instrument by RAMSDEN; a moveable astronomical quadrant, of 2 foot radius, by MACULLOCH; an equatorial instrument by SISSON and RAMSDEN; an achromatic telescope and a divided object glass micrometer by DOLLOND; an astronomical clock, with a gridiron pendulum, by MARIOTTE. To these were added an assistant clock by GADBY, Aberdeen; an alarm clock; a barometer and thermometer, the two last by MILLER, Edinburgh.

THE transit instrument, and the equatorial, were presents from the late Earl of BUTE, at that time Chancellor of the University. They are both instruments of great value; the transit, in particular, is said to be of singular excellence, and altogether worthy of the great artist by whom it was constructed.

THE Observatory, however, such as it is here described, has been but of short continuance. About three years ago barracks were built on the Castle Hill, immediately to the north of the Observatory; and as it appeared to be of consequence, that the ground occupied by the latter should belong to the barracks, it was purchased by Government, and the Observatory demolished. It is to be rebuilt, however, on an improved plan, and in a situation where it will be less incommoded by the vicinity of the town than formerly, and where, it is hoped, the series

series of observations may be continued, which Dr MACKAY has begun with so much diligence and accuracy.

ACCORDING to Dr MACKAY, the latitude, from a mean of 64 observations of the sun's meridian altitude, is $57^{\circ}.9'.1''$, or because the sun's semidiameter, taken from the *Nautical Almanac*, is about $1\frac{1}{2}''$ too great, it is more exactly $57^{\circ}.8'.59\frac{1}{4}''$, and this agrees to $\frac{1}{4}$ of a second with the mean of 8 observations of the meridian altitudes of fixed stars.

THE longitude, determined also by a mean of several observations, is $0^h.8'.32''$ of time, or $2^{\circ}.8'$ west of Greenwich.

HENCE it appears, that the best maps and charts require some correction in the position they assign to Aberdeen, and probably to a great part of the east coast of Scotland. AINSLEY's map places Aberdeen in latitude $57^{\circ}.5'.9''$, which is $3'.50''$ too far south: It is however very exact in the longitude, which it makes $1^{\circ}.6'$ east of Edinburgh; so that, reckoning the longitude of Edinburgh $3^{\circ}.14'.45''$ west of Greenwich, as it is nearly, there remains $2^{\circ}.8'.45''$ W. for the longitude of Aberdeen.

M. DE LA ROCLETTE, in a chart of the north sea, constructed with great skill and accuracy, lays down Aberdeen in latitude $57^{\circ}.5'$, and in longitude $2^{\circ}.21'.31''$ west from Greenwich; so that there is an error of nearly $4'$ in the latitude, and $13'$ in the longitude. It is likely that the latter affects the position of the coast for a considerable extent.

Phys. Cl. A Report concerning the Weather in 1796 was communicated by Mr PLAYFAIR. [See this volume, the last Article of Part II.

1797.
Feb. 6.
Mr Playfair on
the weather of
1796.

APPEN-

APPENDIX.

OFFICE-BEARERS of the SOCIETY.

OFFICE-BEARERS elected for the ensuing Year, at the General Meeting held for that Purpose, 25th November 1793.

Office-bearers of the Society.

President.

His Grace the Duke of BUCCLEUGH.

Vice-Presidents.

Lord Dunfinnan.

Right Hon. Henry Dundas.

Secretary.

Professor John Robison.

Treasurer.

Mr Alexander Keith.

Phys. Cl.

Counsellors.

Lit. Cl.

Mr Benjamin Bell.

Mr Greenfield.

Mr George Fergusson.

Dr Gregory.

Dr Rutherford.

Professor Stewart.

Lord Craig.

General Fletcher Campbell.

Mr Mackenzie.

Lord Dregborn.

Commissioner Edgar.

Mr David Hume.

OFFICE-

Office-bearers of
the Society.

OFFICE-BEARERS of the SOCIETY.

PHYSICAL CLASS.

Presidents.

<i>Dr Black.</i>		<i>Dr Home.</i>
<i>Dr Hutton.</i>		<i>Dr Monro.</i>

Secretaries.

<i>Professior Playfair.</i>		<i>Dr Walker.</i>
-----------------------------	--	-------------------

LITERARY CLASS.

Presidents.

<i>Mr Baron Gordon.</i>		<i>Dr Hugh Blair.</i>
<i>Sir William Miller.</i>		<i>Dr Adam Fergusson.</i>

Secretaries.

<i>Mr Frazer Tytler.</i>		<i>Professior Dalzel.</i>
--------------------------	--	---------------------------

At the General Meetings in 1794, 1795, and 1796, the same office-bearers were elected.

LIST

*LIST of MEMBERS or FELLOWS of the ROYAL SOCIETY of
EDINBURGH, continued from the third Volume. [History of
the Society, Appendix.]*

THE following Members were elected at the General Meeting,
Jan. 27. 1794.

Members cho-
sen, Jan. 27.
1794.

NON-RESIDENT.

The Reverend *John Brougham* of Brookhill, county of Cavan,
Ireland. L.

The Reverend *Dacre Carlyle*, A. M. L.

James Glenie, Esq; F. R. S. Lond. P.

THE following were elected at the General Meeting, Jan. 26.
1795.

Members cho-
sen, Jan. 26.
1795.

RESIDENT.

The Reverend *George Baird*, D. D. Principal of the University
of Edinburgh.

Robert Hamilton, Esq; Advocate.

The Reverend *Thomas Hardy*, D. D. Professor of Church History
in the University of Edinburgh.

Francis Humberston Mackenzie, Esq; of Seaforth.

Alexander Phillip Wilson, M. D. Physician in Edinburgh.

NON-RESIDENT.

John Cooper, M. D. Physician at Fochabers.

William Garsbore, Esq; of London.

John Gillies, LL. D. F. R. S. London, and Historiographer to his Majesty for Scotland.

FOREIGN.

John Godfrey Smeisser, A. M. & F. R. S. London.

Gasper Voght, Esq; of Hamburg.

Members chosen, June 27.
1796.

THE following were elected at the General Meeting, June 27.
1796.

RESIDENT.

Lieutenant-Colonel *Alexander Dirom*, F. R. S. London. P.

The Right Honourable Lord *Fincastle*. P.

The Reverend Sir *Henry Moncrieff-Wellwood*, Bart. D. D. L.

Patrick Murray, Esq; of Ochertyre, Advocate. P.

NON-RESIDENT.

Andrew Berry, M. D. Madras. P.

Sir *Henry Englefield*, Bart. F. R. S. London. P.

Dr *Freer*, Professor of Medicine in the University of Glasgow. P.

Dr *James Gascoigne*, Physician at Plymouth. P.

Richard Kirwan, Esq; F. R. S. London. P.

FOREIGN.

Mark Augustus Pictet, Professor of Philosophy in the Academy of Geneva. P.

M. P. Prevost, Honorary Professor in the Academy of Geneva. P.

THE following were elected at the General Meeting, June 26.
1797.

Members chosen, June 26.
1797.

RESIDENT.

Robert Beatson, Esq; of Kilrie. P.

Dr Andrew Duncan junior. P.

NON-RESIDENT.

The Reverend Walter Fisher, Minister at Cranstoun. P.

The Rev. George Gleig, L.L. D. Episcopal Minister at Stirling. L.

Charles Hatchett, Esq; F. R. S. London. P.

Major James Rennel, F. R. S. Lond. P.

FOREIGN.

John Jeffcot, M. D. F. R. Coll. of Physicians at Stockholm, and
Professor of the Practice of Medicine at Upsal. P.

f 2

LIST

Members deceased.

LIST of MEMBERS who have died since the Publication of the last Volume.

- Colonel *Edmonstone* of Newton. June 24. 1793.
Honourable *James Veitch* of Elliock, (Lord *Elliock*), one of the Senators of the College of Justice. July 1. 1793.
Honourable *Francis Garden*, (Lord *Gardenstone*), one of the Senators of the College of Justice. July 22. 1793.
Abraham Guyot of Neuchatel. May 22. 1794.
John Roebuck, M. D. July 16. 1794.
Reverend Dr *Bell*, Minister at Coldstream. August 9. 1794.
Right Honourable Lord *Daer*. Nov. 5. 1794.
Charles Scott, M. D. Physician in London.
Sir *William Jones*, one of the Judges of the Supreme Court at Bengal, and President of the Asiatic Society.
Alexander Gerard, D. D. Professor of Divinity, King's College, Aberdeen. Jan. 22. 1795.
Sir *Francis Kinloch* of Gilmerton. April 16. 1795.
Rév. *John Main*, D. D. Minister at Newton. May 13. 1795.
William Smellie, Printer in Edinburgh. June 24. 1795.
Adair Crawford, M. D. Physician to St Thomas's Hospital, London, and Professor of Chemistry in the Academy at Woolwich. August 5. 1795.
Honourable *Alexander Abercromby*, (Lord *Abercromby*), one of the Senators of the College of Justice. Nov. 17. 1795.
James Robertson, D. D. Professor of Oriental Languages in the University of Edinburgh. Nov. 25. 1795.

John.

John Anderson, L.L. D. Professor of Natural Philosophy in the University of Glasgow. Jan. 13. 1796.

George Campbell, D. D. Principal of the Marishall College, Aberdeen. April 6. 1796.

Thomas Reid, D. D. Emeritus Professor of Moral Philosophy in the University of Glasgow. Nov. 7. 1796.

Honourable *John MacLaurin*, (Lord Dregborn), one of the Senators of the College of Justice. Dec. 24. 1796.

Thomas Gordon, Professor of Philosophy, King's College, Aberdeen. March 11. 1797.

James Hutton, M. D. March 26. 1797.

Archibald Arthur, A. M. Professor of Moral Philosophy in the University of Glasgow. June 1797.

ANON-

List of Donations.

*DONATIONS presented to the ROYAL SOCIETY OF EDINBURGH,
continued from the preceding Volume.*

From the Author.

Charts of the China Navigation, fol. by *George Robertson*, Esq;
F. R. S. Edin. and now Commander of the *Berrington*, East
Indiaman.

From the Author.

Historical and Biographical Sketches of the Progress of Botany
in England, 2 vol. 8vo, 1790, by *Richard Pulteney*, M. D.
and F. R. S.

General View of the Writings of LINNÆUS, 8vo, 1781, by the
same.

From the Reverend *Andrew Brown*.

A Model of an Indian Canoe, with the Belt and Pouch of an In-
dian Hunter. 1794.

From the Author.

System of Mineralogy, 2 vol. 8vo, 1795, by *J. G. Smeyffer*,
F. R. S. Lond. & Edin.

From the Author.

Report of a Survey of the Thames, 8vo. 1794, by Mr *John
Rennie*, Engineer, F. R. S. Edin.

From the Literary and Philosophical Society at Manchester.
Manchester Memoirs, vol. iv. Part 2. 1794.

From

From the American Academy of Arts and Sciences.

Memoirs of the Academy, vol. ii. part 1. Boston, 1793.

From the Author.

Ueber die Bleyglasur unserer Topferwaare, vom Hofrath, G. A. Ebell. Hannover, 1794.

From the Editor, *Francis Maseres*, Esq; Curfitor Baron of Exchequer.

Scriptores Logarithmici, or a Collection of Curious Tracts on the Nature and Construction of Logarithms, 3 vol. 4to. 1791, 1796.

From *John Thomas Stanley*, Esq;

Three Views of Geyser, a hot Spring in Iceland, from Drawings taken on the Spot.

From the Royal Society of London.

Transactions of the Royal Society of London from 1790 to 1794.

From the Author.

Remarks on the Antiquities of Rome and its Environs, 4to, 1797, by *Andrew Lumisden*, Esq; F. R. S. Edin.

From M. *Chevalier*, F. R. S. Edin.

On the pretended Tomb of HOMER, 4to. 1797.

From the American Academy of Arts and Sciences

Memories of the Academy, vol. 1, Boston, 1841

Memories of the Academy, vol. 2, Boston, 1842

Memories of the Academy, vol. 3, Boston, 1843

Memories of the Academy, vol. 4, Boston, 1844

Memories of the Academy, vol. 5, Boston, 1845

Memories of the Academy, vol. 6, Boston, 1846

Memories of the Academy, vol. 7, Boston, 1847

Memories of the Academy, vol. 8, Boston, 1848

Memories of the Academy, vol. 9, Boston, 1849

Memories of the Academy, vol. 10, Boston, 1850

Memories of the Academy, vol. 11, Boston, 1851

Memories of the Academy, vol. 12, Boston, 1852

Memories of the Academy, vol. 13, Boston, 1853

Memories of the Academy, vol. 14, Boston, 1854

Memories of the Academy, vol. 15, Boston, 1855

Memories of the Academy, vol. 16, Boston, 1856

Memories of the Academy, vol. 17, Boston, 1857

Memories of the Academy, vol. 18, Boston, 1858

Memories of the Academy, vol. 19, Boston, 1859

Memories of the Academy, vol. 20, Boston, 1860

L. ACCOUNT of the LIFE of Lord ABERCROMBY. By HENRY
MACKENZIE, Esq; F. R. S. EDIN.

[Read by the Author, Feb. 15. 1796.]

THE life of which I am about to give some account to this Society cannot be called a literary one; of literary lives only it is perhaps the proper business of the *Royal Society* to record the particulars; but it has been in the practice of allowing a wider range to this customary notice of its deceased Members. Of the lives of such as were eminent in station or in usefulness, in abilities or in virtue, it has been accustomed to hear a narrative, which, though not important to learning, is interesting to humanity. Under this title, it will indulge me with a short account of the life of LORD ABERCROMBY.

HE was the youngest son of GEORGE ABERCROMBY of Tullibody, a gentleman of a respectable family and considerable fortune in Stirlingshire, and of ANNE DUNDAS, daughter of Mr DUNDAS of Manor. He was born on the 15th day of October 1745. His father still lives at the very advanced age of 91, and has had the singular good fortune to see two of his elder sons, who were both bred soldiers, appointed Commanders in Chief of the British forces, one in the West and the other in the East Indies, the most important stations with which their country could entrust them. His age indeed has, within

Account of Lord
Abercromby.

these few months, been clouded by the death of him who is the subject of this paper; but it is something for a father, it is something for his friends, to mix their sorrows with the general regret of his country.

HIS youngest son ALEXANDER was early destined for the profession of the law, to which his father had himself been bred, at a time when the *Faculty of Advocates* comprehended one half of the gentlemen of Scotland. At that period, commerce and manufactures had not attained, in this part of the kingdom, that extension and improvement which renders them objects of pursuit to men of birth or fortune. The sword and the gown were here the only professions suited for such men; for our church did not, like those of England and France, offer endowments considerable enough to attract the interested or to excite the ambitious. In Scotland, however, the profession of the law was adopted by the eldest sons of the gentry, rather as conferring a sort of fashionable distinction, than as one from which they looked for business or emolument. It led to a learned, or at least a polite education, and gave a sort of dignity beyond the mere idleness of a man of pleasure. Hence perhaps there was in those times an elegance of manners, joined with a degree of knowledge and information, among the *Faculty of Advocates* in Scotland, not to be met with among any similar body of men in any other country. I mention this historically, because it does not perhaps exactly subsist at present, from causes which may be held not to improve the manners so much as, in a political and commercial view, they may be supposed to meliorate the situation of a country.

Mr ABERCROMBY, with a view to the law, which his prospects made it necessary for him to follow as a profession, received the customary education at the University of Edinburgh. There the writer of this memoir first knew him. He had abilities which qualified him for being more a scholar, than the
vivacity

vivacity of his disposition then allowed him to become. With uncommon beauty of countenance and pleasantness of manner, the favourite of every relation and acquaintance, he did not then (as is common with young men so circumstanced) apply to his studies with the constant and unremitting assiduity which is calculated to attain deep learning. But he had a readiness and acuteness that could easily perform his exercises when he wished to perform them. After going through the ordinary course of classes at the University, consisting of the Latin and Greek languages, of Logic, Philosophy, the Civil and Scots Law, he was admitted Advocate in the year 1766.

Account of Lord
Abercromby.

FOR some time after his coming to the bar, he retained somewhat of that gaiety of deportment and of conduct, which are not exactly suited to the dry and uninviting paths that conduct men to legal eminence. His manners and disposition were better fitted for the less serious and more engaging society of men of fashion and pleasure. During several years he lived a good deal in such society, and gave but little promise of that attention and application to business for which he was afterwards distinguished. Though not unremittingly attentive, however, to his profession, he was never neglectful of its duties; and when any particular case was put into his hands, he gave very convincing proofs, both of his general talents, and of his power of application to business in detail.

BUT it was not long before he felt the propriety of secluding himself more than he had hitherto done from the scenes of conviviality and amusement, which had interfered with a more serious and determined application to his profession. He had lent to lighter society a certain gaiety and sportfulness of mind, which, in a character of less native vigour and ability, might have been fatal to the future prospects of his life. But he possessed an intrinsic character, which it was not difficult for him to resume; and from that pride and dignity of soul which he

Account of Lord
Abercromby.

always maintained in an uncommon degree, he felt it unworthy of him not to make every effort for rising into eminence in the profession which he had chosen, from which, being a younger son, and not likely to be possessed of a large patrimony, he was to derive support and independence.

AN opportunity soon occurred of drawing the attention of the Court in which he practised, and indeed of the country at large, to the talents which he possessed, and to that exertion of them which he could command. He was counsel in a cause, which, from its peculiar circumstances, had attracted much public curiosity, and divided for some time the public opinion. This was the case of *Wilson and Maclean*, in which a particular fact (the period of the death of a shipmaster, from whom a receipt was produced in bar of the plaintiff's claim, but which receipt was alleged to be a forgery) was involved in so much uncertainty, and that uncertainty strengthened by the opposite depositions of such a number of witnesses, that it became a question of uncommon notoriety and expectation, not only from the extraordinary circumstances of that individual cause, but as involving a general legal consequence of the incertitude of oral testimony in fixing the date of not very distant events. In this cause Mr ABERCROMBY was employed for the pursuer or plaintiff, and made a speech, in opposition to one of equal ability from Mr BLAIR, now Solicitor-General, so conspicuous for the closeness of its deduction, the force and clearness of its argument, the eloquence and impressive sensibility of its declamation, as to excite a very strong sensation at the bar and in the public, and to mark him as an Advocate from whom the most strenuous and successful exertions were to be expected. It is seldom that at the bar of *Scotland*, any appearance, however brilliant, has much effect in bringing a counsel into professional celebrity or employment. From the constitution of the Supreme civil Court in this country, where trial by jury does not take place,
and

and from the nature of its proceedings, which are chiefly carried on by *written* arguments, a speech, however remarkable, is rarely followed by those important consequences to a barrister's future business, of which there are daily instances in *Westminster Hall*. But in this case Mr ABERCROMBY's appearance made such an impression in his favour as very soon to place him among the most rising young men of the profession. He took advantage of this circumstance by a step, of which the expediency was doubted by many of his friends at the time, but was afterwards allowed by them all. Soon after his being called to the bar, he had been appointed Sheriff-depute of *Stirling-shire*, which he now (in 1780) resigned for the less lucrative and more precarious situation of *Depute-Advocate*, on the idea of the latter office being more beneficial in its consequences, as not precluding him from business arising within the county of *Stirling*, where he had many connections both from relationship and acquaintance, but rather tending to advance his employment, from the opportunities it afforded him of appearing in public and criminal cases. This appointment of *Depute-Advocate* he held under Mr HENRY DUNDAS, then Lord Advocate for Scotland, in conjunction with Mr BLAIR, since his Majesty's Solicitor, and Mr CRAIG, now a Judge in the Courts of Session and Justiciary. Those two gentlemen and Mr ABERCROMBY were as much connected in private friendship as in public business; a friendship to which one who has known them long and intimately, may be pardoned for ascribing a considerable advantage towards the attainment of that professional eminence, as well as of that general estimation and respectability which they have all enjoyed.

Mr ABERCROMBY now rose with great rapidity in his profession, and was among the best employed barristers of his standing in Scotland. To this success he was not more entitled by his talents than by his assiduity; and it was a peculiar merit in him,
who

Account of Lord
Abercromby.

(6) *HISTORY of the SOCIETY.*

Account of Lord
Abercromby.

who had once indulged so much in gaiety and amusement, and who was so much fitted by nature to shine among the gay and the amusing, to devote himself now to business with a rigid attention and punctuality not always met with even among men of the most grave and serious dispositions. His speeches and his papers were held in equal estimation. His general method in both was, to state the *fact* which gave origin to the cause simply and perspicuously, and then to apply those principles and arguments in *law* which bore upon the case, from which he drew the conclusion in favour of his client. When the case admitted of it, he was fond of illustrating his argument by some apposite classical allusion, or some anecdote of ancient or modern times, with which his memory was abundantly stored. His expression was always elegant, and when the subject called for it, rose to a degree of animation and eloquence much beyond what business-men might think necessary in a mere legal pleading. He excelled particularly in that indignant tone in which a good man rebukes injustice or oppression, and that pathetic in which he pleads the cause of the unfortunate; a style which his own mind, nice as it was in honour, and open to compassion, naturally prompted.

THE laborious employments of his profession did not so entirely engross him as to preclude his indulging in the elegant amusements of polite literature. He was one of that society of gentlemen, who, in 1779, set on foot the periodical paper, published at Edinburgh, during that and the succeeding year, under the title of the *MIRROR*, and who afterwards gave to the world another work of a similar kind, the *LOUNGER*, published at Edinburgh in 1785 and 1786. To these publications he was a very valuable contributor, being the author of ten papers in the *Mirror* and nine in the *Lounger*. His papers are distinguished by an ease and gentlemanlike turn of expression, by a delicate and polished irony, by a strain of manly, honourable

nourable and virtuous sentiment. In some of them we find that unaffected tenderness, of which I took notice above as frequently distinguishing his professional labours. One of those papers I have often read since his death, with feelings which I believe to be so much in unison with those of my present audience, that I hope I shall not be thought to trespass on their time or patience, if I quote the conclusion now. In N^o 90. of the *Mirror*, he mentions as one of the calamities of extremely lengthened life, the loss of friends, and gives a very natural and affecting account of his own feelings on an occasion of that sort. The picture contained in that paper is no *fancy-drawing*; it is a portrait of one of the earliest and most excellent friends of Mr ABERCROMBY, and of the writer of this memoir, Mr GORDON of *Newball*, whose accomplishments and whose virtues will not be soon forgotten by some members of this Society. Alas! I did not imagine, when I heard Mr ABERCROMBY read that paper of the *Mirror*, that, in a few years, it should be applicable to the loss of its Author! If any of those who now participate in this reflection, should one day have occasion to recal in this place the remembrance of him who reads the present account, may his memory be as dear to his friends, and as valuable to society, as those to whom his feeble words now endeavour to do justice!

Account of Lord
Abercromby.

“ THERE is one circumstance (says Mr ABERCROMBY, in the paper I allude to) which with me is alone sufficient to decide the question (whether long life be an object much to be desired). If there be any thing that can compensate the unavoidable evils with which this life is attended, and the numberless calamities to which mankind are subject, it is the pleasure arising from the society of those we love and esteem. Friendship is the cordial of life. Without it, who would wish to exist an hour? But every one who arrives at extreme old age, must

Account of Lord
Abercromby.

must make his account with surviving the greater part, perhaps the whole, of his friends. He must see them fall from him by degrees, while he is left alone, single and unsupported, like a leafless trunk, exposed to every storm, and shrinking from every blast.

“ I HAVE been led to these reflections by a loss I lately sustained in the sudden and unlooked-for death of a friend, to whom, from my earliest youth, I had been attached by every tie of the most tender affection. Such was the confidence that subsisted between us, that, in his bosom, I was wont to repose every thought of my mind, and every weakness of my heart. In framing him, nature seemed to have thrown together a variety of opposite qualities, which, happily tempering each other, formed one of the most engaging characters I have ever known. An elevation of mind, a manly firmness, a *Castilian* sense of honour, accompanied with a bewitching sweetness, proceeding from the most delicate attention to the situation and the feelings of others. In his manners simple and unassuming; in the company of strangers modest to a degree of bashfulness; yet possessing a fund of knowledge, and an extent of ability, which might have adorned the most exalted station. But it was in the social circle of his friends that he appeared to the highest advantage; there the native benignity of his soul diffused, as it were, a kindly influence on all around him, while his conversation never failed at once to amuse and to instruct.

“ NOT many months ago I paid him a visit at his seat in a remote part of the kingdom. I found him engaged in embellishing a place, of which I had often heard him talk with rapture, and the beauties of which I found his partiality had not exaggerated. He shewed me all the improvements he had made, and pointed out those he meant to make. He told me all

all his schemes, and all his projects. And while I live, I must ever retain a warm remembrance of the pleasure I then enjoyed in his society.

Account of Lord
Abercromby.

"THE day I meant to set out on my return, he was seized with a slight indisposition, which he seemed to think somewhat serious; and, indeed, if he had a weakness, it consisted in rather too great anxiety with regard to his health. I remained with him till he thought himself almost perfectly recovered; and, in order to avoid the unpleasant ceremony of taking leave, I resolved to steal away early in the morning, before any of the family should be stir. About daybreak I got up, and let myself out. At the door I found an old and favourite dog of my friend's, who immediately came and fawned upon me. He walked with me through the park. At the gate he stopped, and looked up wishfully in my face; and, though I do not well know how to account for it, I felt, at that moment when I parted with the faithful animal, a degree of tenderness, joined with a melancholy so pleasing, that I had no inclination to check it. In that frame of mind I walked on (for I had ordered my horses to wait me at the first stage) till I reached the summit of a hill, which I knew commanded the last view I should have of the habitation of my friend. I turned to look back on the delightful scene. As I looked, the idea of the owner came full into my mind; and, while I contemplated his many virtues and numberless amiable qualities, a suggestion arose, if he should be cut off, what an irreparable loss it would be to his family, to his friends, and to society. In vain I endeavoured to combat this melancholy foreboding, by reflecting on the uncommon vigour of his constitution, and the fair prospect it afforded of his enjoying many days. The impression still recurred, and it was some considerable time before I had strength of mind sufficient to conquer it.

Account of Lord
Abercromby.

" I HAD not been long at home when I received accounts of his being attacked by a violent distemper, and in a few days after I learned that it had put an end to his life.

" THIS blow, for a time, unmanned me quite. Even now, the chief consolation I find is in the society of a few chosen friends. Should they also be torn from me, the world would to me be as a desert ; and, though I should still endeavour to discharge my duty in that station which Providence has assigned me in life, I should never cease to look forward, not without impatience, to those peaceful mansions where the weary are at rest, and where only we can hope to meet again with those from whom we have been parted by the inexorable hand of death."

IN 1792, when in this high and advancing situation at the bar, an offer was made to him of the appointment of Judge of the Court of *Session*, in the room of Lord ROCKVILLE, deceased. This appointment he hesitated for a considerable time to accept, from an idea he had formed of the difficulty of executing the office in that manner in which he conceived it ought to be executed, and of the laborious and fatiguing application and exertions of mind which its various duties required. He was at length prevailed on to accept of it, principally from the very handsome manner in which it was offered to his acceptance, and in compliance with the wishes of his friend Mr Secretary DUNDAS, who knew, from early and continued acquaintance, the value of that acquisition which he wished the Bench to make, in the appointment of Mr ABERCROMBY to a Judge's seat. That appointment accordingly took place on the 30th of May 1792 ; and on the 14th of December following, he was called to a seat in the Court of *Jusficiary*, on the vacancy occasioned by the death of Lord HAILES.

THE manner in which he executed those very important offices, is fresh in the memory of every one. To the most assiduous and unremitting attention to his duty, and the most accurate consideration of the legal principles which were to determine his decision, he joined a talent for announcing that decision, and the grounds on which it rested, in such a manner as to give singular weight and dignity to his opinion, and to make the strongest impression on his audience. He did not speak often, but when he did, he never failed to throw light on the case before the Court. He never forgot, (what is liable to be forgotten in a Court which, from the number of its Judges, partakes somewhat of the nature of a popular assembly), that he was delivering the opinion of a Judge, not arguing the cause of a barrister. He never replied to any of his brethren, remembering that a Judge does not speak for victory; that it is his business to pronounce his own opinion, not to combat the opinions of others. He spoke shortly, seldom on the circumstances of the case in detail, but on some leading and prominent point on which the opinion he was to deliver was founded. His expression was clear and perspicuous, correct, at the same time, and elegant. His speaking was slow and deliberate, and in that cool and solemn manner which becomes a judicial opinion; yet, like his appearances at the bar, it did not fail in animation when it was directed to the censure of unfairness, to the detection of dishonesty, or to the rebuke of oppression. He was of particular use in the civil Court, by an attention to the proceedings, and to the checking of any impropriety in the conduct of the business. On this ground, his own strict observance of propriety gave him great advantage. When he did censure, even when there was occasion for severity, it was with so much gravity and dignity of manner, and so much temperance of expression, as to ensure the approbation

Account of Lord
Abercromby.

Account of Lord
Abercromby,

of the impartial, as to impress conviction, as well as to impose silence, on the censured. Lord ABERCROMBY possessed those virtues and accomplishments which invest the station of a Judge with an authority the most venerable and the most persuasive. Purity of mind and of character, a nice sense of honour and decorum, a delicacy of private and a dignity of public deportment; these are at all times most important qualities in a Judge; at no time perhaps so much as at the present, when they are so essential to conciliate the esteem and to command the reverence of the people for the magistracy and constitution of their country.

To the *criminal Court* those qualities are peculiarly appropriate. In that Court, the Judge is the organ of the offended majesty of the law; his deportment ought to be suited to that function, grave, deliberate, decided. Above the atmosphere of the passions, he may speak with severity, but never with resentment; and his duty is too solemn and too majestic, to admit of the light or the frivolous, either in manner or expression. Yet, amidst the unbending declaration of the law, and the steady decision of its minister, he may, and in some cases ought to feel that dignified compassion for human frailty, that tempers the rigour, but does not detract from the awfulness of justice. Such was the deportment of Lord ABERCROMBY. The firmness of his mind, and the dignity of his demeanour, were particularly called forth at that momentous juncture, when the decisions of the criminal Court of Scotland vindicated the laws, and upheld the constitution, against the daring attacks of turbulence and sedition.

THE last piece of duty which Lord ABERCROMBY performed as a Judge of the Court of Justiciary, (immediately after the admission of his friend Lord CRAIG as a colleague), was the northern circuit in the spring of the year 1795. On that jour-

ney

Account of Lord
Abercromby.

ney he felt himself a good deal indisposed, but returned to Edinburgh, restored, as he said, to his usual health, though his altered looks and appearance strongly excited the apprehensions of his friends. Those apprehensions were but too soon verified. He was attacked in summer 1795 with a breast-complaint, attended with dangerous symptoms, for which, after some palliative means, to which his disorder never at all yielded, he was advised to try the milder climate of *Exmouth* in Devonshire, a voyage to the Continent being, in the present situation of public affairs, difficult to accomplish, and particularly disagreeable to his inclinations. He was accompanied in this journey by his nephew, the eldest son of his brother Sir RALPH ABERCROMBY, who watched the last days of his uncle with that tender assiduity which, though the world can neither see its merit nor feel its sufferings, is one of the most important and most disinterested of all the domestic duties. On the road to *Exmouth*, he was seized with still more violent symptoms than any his disorder had hitherto exhibited; and though he experienced, during the space of about two months, some temporary relief, he never gained any material advantage, and the disease made progressive advances, till at last it carried him off on the 17th day of November 1795. He bore its sufferings with the greatest patience and fortitude; and though for some time he entertained hopes which his physicians and friends saw to be but too ill founded, he met its conclusion with perfect composure and resignation.

THE disorder which terminated so fatally was perhaps only the effect of a gradually debilitated constitution, not of any determinate and immediate cause. Yet some of his friends, with an anxiety natural in such a circumstance, have traced it to various sources. An accidental fall into the uninclosed foundation of a house in the New Town of Edinburgh, was by
1
some,

Account of Lord
Abercromby.

some, I believe not on any medical authority, supposed to have produced the complaint to his breast. The anxiety and application he bestowed on the duties of a very laborious profession, might contribute to exhaust the strength of his constitution; and, if mental affections are to be allowed such force, the uneasiness which for some years he experienced on the subject of public affairs and the political state of his country, might impair and weaken his health and spirits. Deeply impressed himself with the excellence of the British constitution, and of the happiness derived from it, he saw with horror and indignation (at a period considerably earlier than that which excited the apprehensions of most other people) the efforts of desperate and designing men to overturn it; he lamented the delusion of those who were misled to join them; and he trembled for the effects of that delusion in estimable and benevolent but visionary minds, who might indulge the pride of political theory and speculation, to the danger, as he conceived, of all good order and regular government, of all social happiness and social virtue.

OF the public virtues of Lord ABERCROMBY, I have given a pretty full detail, because those speak loudest in example, and are most generally useful to mankind. Of his private virtues and accomplishments I might speak in this Society on the testimony of many of its Members, who will long remember the excellence of his disposition, the worth and honour of his heart, the amiable and engaging manners which he exhibited. From birth, from education, from native sentiment, and improved society, he cultivated, and was never a moment unimpressed with the feelings of a *gentleman*, with that delicacy of mind, "above the fixed and settled rules," which polishes the manners, which refines morality, which dignifies virtue; of which such an example is the more valuable in these days, when

I am afraid a style of life and manners has become in some degree fashionable, which destroys this honourable distinction ; which degrades the higher ranks by vices and follies that used to be a reproach to the least worthy among the lower ; in which name and station sanctify grossness in pleasure and coarseness in demeanour, and wealth shoots out into caprice and absurdity, instead of expanding into generosity and usefulness.

Account of Lord
Abercromby.

THE Society will pardon this digression, which I confess to be unnecessary, and to some may appear ungracious ; they will forgive it to him who, looking from the tomb of his friend on the world he has left, with that gentler misanthropy (if it shall be thought to merit that term) which is made up rather of regrets than of resentments, naturally enough indulges in an aggravation of what he has lost, and, it may be, in an unfavourable estimate of what remains for him to enjoy.

INDEPENDENTLY, however, of the estimation of friendship, it may certainly be affirmed, that in the death of Lord ABERCROMBY society has sustained a loss of no light nor common kind ; a loss which his friends and acquaintance will long and deeply lament ; and which, without disparagement to the virtues or the abilities of his survivors, will not be easily repaired to the public.

II. *A short Account of the Life and Writings of WILLIAM TYTLER, Esq; of Woodhouselee, F. R. S. EDIN. By HENRY MACKENZIE, Esq; F. R. S. EDIN.*

[Read by the Author, June 20. 1796.]

THE custom which this Society has established, of giving some account of the lives of its deceased members, is in every case gratifying to friendship, in many interesting to curiosity, but in those which serve to record the pursuits and occupations of men of letters, it is more strictly and properly an object coming within the views of a literary institution. The history of the authors is always in a great degree the history of the literature of a country; and even exclusive of an immediate relation to their works, the narrative of their private and domestic habits is often, in a moral point of view, useful and interesting to the scholar and the author. In both these respects, I may claim the attention of the Society to the following short account of the life and writings of our late worthy colleague, Mr WILLIAM TYTLER.

Mr TYTLER was the son of Mr ALEXANDER TYTLER, writer in Edinburgh, by JANE, daughter of Mr WILLIAM LESLIE, merchant in Aberdeen, and grand-daughter of Sir PATRICK LESLIE of Iden, Provost of Aberdeen. He was born at Edinburgh, October 12. 1711. He received his education at the High School and University of his native city, and distinguished

VOL. IV. (C) guished

Account of
W. Tytler, Esq;

guished himself by an early proficiency in those classical studies, which, to the latest period of his life, were the occupation of his leisure hours, and a principal source of his mental enjoyments.

IN the year 1731, he attended the academical lectures of Mr ALEXANDER BAYNE, Professor of Municipal Law in the University of Edinburgh, a gentleman distinguished alike for his professional knowledge, his literary accomplishments, and the elegance of his taste. The Professor found in his pupil a congenial spirit, and their connection, notwithstanding the disparity of their years, was soon ripened into all the intimacy of the strictest friendship. So strong indeed became at length that tie of affection, that the worthy Professor, in his latter years, not only made him the companion of his studies, but when at length the victim of a lingering disease, chose him as the comforter of those many painful and melancholy hours which preceded his death.

AT the age of thirty-one, Mr TYTLER was admitted into the Society of *Writers to his Majesty's Signet*, and continued the practice of that profession with very good success, and with equal respect from his clients and the public, till his death, which happened on the 12th of September 1792. He married, in September 1745, ANNE CRAIG, daughter of Mr JAMES CRAIG of Dalnair, writer to the Signet, by whom he has left two sons, ALEXANDER FRASER TYTLER, his Majesty's Judge-Advocate for Scotland, and Professor of Civil History in the University of Edinburgh, and Major PATRICK TYTLER, Fort-Major of the Castle of Stirling; and one daughter, Miss CHRISTINA TYTLER. His wife died about nine years before him, and previously to that period, he had lost a son and a daughter, both grown to maturity.

It is perhaps only in smaller communities, like that of *Edinburgh*, that the union of business and literary studies can easily take place. In larger societies, such as that of *London*, here the

the professional objects are greater and more extensive, and the different classes of men are more decidedly separated from one another, there is a sort of division of mind as well as of labour, that makes the lawyer or the merchant a perfect lawyer or merchant, whose mind and time are wholly engrossed by the objects of his profession, and whom it might considerably discredit among his brethren of that profession, were he to devote any portion of either to classical study or literary composition. In Edinburgh it is otherwise; the professional duties are not in general so extensive as to engross the whole man, and his connections in society extending through many different classes of his fellow-citizens, he has opportunities of conversing, of reading, and of thinking on other objects than merely those immediately relating to the business which he follows. This is perhaps the most agreeable state of society of any, which, if it may sometimes prevent the highest degree of professional eminence and skill, (though even on that ground many arguments might be offered in its favour), certainly tends to enlarge the mind, and to polish the manners; to give a charm and a dignity to ordinary life, that may be thought ill exchanged for the inordinate accumulation of wealth, or the selfish enjoyment of professional importance.

Account of
W. Tytler, Esq.

AMONG that Society of which Mr TYTLER, at the period I have mentioned, was admitted a member, the *Writers to the Signet*, there were always many individuals possessed of much general learning and knowledge; and the classical education which was generally bestowed on young men destined for that Society, frequently led them to indulge in historical and literary disquisitions, little connected with the ordinary course of their professional employments. Mr TYTLER was one of those who, from his earliest years, had applied himself to letters and classical study; and amidst an accurate knowledge and unremitting attention to his business, he never ceased to cultivate and to enjoy them.

Account of
W. Tytler, Esq;

THE most remarkable feature of Mr TYTLER's character was an ardour and activity of mind, prompted always by a strong sense of rectitude and honour. He felt with equal warmth the love of virtue and the hatred of vice; he was not apt to disguise either feeling, nor to compromise, as some men more complying with the world might have done, with the fashion of the time, or the disposition of those around him. He seldom wavered an argument on any topic of history, of politics or literature; he never retreated from one on any subject that touched those more important points on which he had formed a decided opinion. Decided opinions it was his turn to form; and he expressed them with a warmth equal to that with which he felt them. He took strong common-sense views of objects, not from want of acuteness to perceive less palpable relations, but from that warm and ardent cast of mind to which such views are more congenial than the subtleties of abstract or metaphysical disquisition.

NOR was it in opinion or argument only that this warmth and ardour of mind were conspicuous. They prompted him equally in action and conduct. His affection to his family, his attachment to his friends and companions, his compassion for the unfortunate, were alike warm and active. He was in sentiment also what JOHNSON (who felt it strongly in himself, and mentions it as the encomium of one of his friends) calls a *good biter*; but his hatred or resentment went no further than opinion or words, his better affections only rose into action. In his opinions, or in his expression of them, there was sometimes a vehemence, an appearance of acrimony, which his friends might regret, which strangers might censure; but he had no asperity in his mind to influence his actual conduct in life. He indulged opposition, not enmity; and the world was just to him in return; he had opponents, but I sincerely believe not a single enemy. His contests were on opinions, not on things; his disputes were historical and literary. In conversation, he

carried

carried on these with uncommon interest and vivacity; and the same kind of impulse which prompted his conversation (as is justly observed by an author, who published some notices of his life and character in the periodical work entitled *The Bee*) induced him to become an author. He wrote not from vanity or vain-glory, which ROUSSEAU holds to be the only inducement to writing; he wrote to open his mind upon paper; to speak to the public those opinions which he had often spoken in private; opinions on the truth of which he had firmly made up his own conviction, and was sometimes surprised when he could not convince others; it was fair to try, if, by a fuller exposition of his arguments, he could convince the world.

Account of
W. Tytler, Esq.

WITH this view, he published, in 1759, his "Enquiry, historical and critical, into the Evidence against MARY *Queen of Scots*, and an Examination of the Histories of Dr ROBERTSON and Mr HUME with respect to that Evidence;" in which he warmly espoused the cause of that unfortunate Princess, attacked with severity the conduct of her enemies, and exposed the fallacy, in many parts the fabrication, of those proofs on which the charges against her had been founded. This work was the first on that side of this celebrated question which interested the public in general, and appealed in behalf of the Queen to the judgment and feelings of the people. The learned and industrious Mr WALTER GOODALL had several years before published his examination of the *Letters* of MARY, on which her accusers had so much rested as evidence of her guilt; but that examination, however elaborate and acute, was not well calculated, either in form or style, for general perusal. Mr TYTLER's work gave to the arguments of GOODALL the conciseness and compression necessary to command the attention of the reader, supported them by a variety of new proofs and illustrations, and drew from the general history of the period in question, and from the characters of the leading actors of the scene, arguments more impressive and interesting than any which

Account of
W. Tytler, Esq;

which mere verbal criticism of the letters, or an examination of cotemporary documents, could supply. The first editions of the *Enquiry* were in one volume 8vo; but the author afterwards considerably enlarged it, particularly in the historical part, and published, in 1790, an edition (being the fourth) in two volumes of the same size.

THE problem of MARY's guilt or innocence, (to use the language of a near relation of Mr TYTLER's, expressive indeed of Mr TYTLER's OWN sentiments on the subject), if considered merely as a detached historical fact, would appear an object which, at this distance of time, seems hardly to merit that laborious and earnest investigation to which it has given rise; though, even in this point of view, the mind is naturally stimulated to search out the truth of a dark mysterious event, disgraceful to human nature; and our feelings of justice and moral rectitude are interested to fix the guilt upon its true authors. But when we consider that this question involves a discussion of the politics of both England and Scotland during one of the most interesting periods of their history, and touches the characters, not only of the two sovereigns, but of their ministers and statesmen, it must then be regarded in the light of a most important historical enquiry, without which our knowledge of the history of our own country, and of that political connection with England which from that time influenced all State-affairs in Scotland, must be obscure, confused, and unsatisfactory. In addition to these motives of enquiry, this question has exercised some of the ablest heads both of the former and of latter times; and it is no mean pleasure to engage in a contest of genius and of talents, and to try our strength in the decision of a controversy, which has been maintained on both sides with consummate ability.

IF to persons, however, of cooler and less sanguine tempers, it should still appear singular, that any ancient historical disquisition should so keenly engage the minds and the passions of literary

terary men, it may perhaps be observed, that it is on objects of this sort that these are frequently more occupied and excited than on others which might at first sight appear better calculated to occupy and excite them. On objects of present and immediate concern, the mind and the affections have certain limits to which the actual and known interest necessarily confines them. The others have a sort of ideal range which no such fixed and certain boundary restrains. The interest is created, not found, and the fancy fosters and nourishes the subject of its own creation, till it engrosses the attention and excites the passions to a degree that must appear very extraordinary to those who consider it in its natural and unexaggerated colours. Disputes of literary as well as political enthusiasm, have therefore been generally the most obstinate and warm of any; and this, which is quaintly termed the *Marian* controversy, of all such disputes the keenest. Even Mr HUME, placid as he was from nature, and accustomed, from his earliest literary life, to contradiction and attack, lost somewhat of his usual temper on the occasion, and subjoined an angry note to the latter editions of his History, which I shall not quote, because, from my respect for his memory, I am rather inclined to wish that it had not been written.

Account of
W. Tytler, Esq;

WITHOUT venturing any opinion on the question itself, it may be sufficient in this place to say, that Mr TYTLER acquired high reputation by his discussion of it. The *Enquiry* was universally read in Britain, and very well translated into French, under the title of "Recherches Historiques et Critiques sur les principales Preuves de l'Accusation intentée contre MARIE Reine d'Ecosse." The interest it excited among literary men, may be judged of from the character of those by whom it was reviewed on its publication, in the periodical works of the time. Dr DOUGLAS, now Bishop of Salisbury, Dr SAMUEL JOHNSON, Dr JOHN CAMPBELL, and Dr SMOLLET, all wrote reviews of Mr TYTLER's book, containing very particular accounts of its merits,

Account of
W. Tytler, Esq;

merits, and elaborate analyses of the chain of its arguments. As an argument on *evidence*, no suffrage could perhaps be more decisive of its merit than that of one of the greatest lawyers, and indeed one of the ablest men that ever sat on the woolsack of England, the late Lord Chancellor HARDWICKE, who declared Mr TYTLER's Enquiry to be the best concatenation of circumstantiated proofs brought to bear upon one point, that he had ever perused. What effect that body of evidence, or the arguments deduced from it, ought to have upon the minds of those to whom the subject becomes matter of investigation, I do not presume to determine. The opinion of the late Dr HENRY, author of *The History of Great Britain on a new Plan*, may perhaps be thought neither partial nor confident; who says, in a letter to Mr TYTLER, published in the volume of *Transactions of the Antiquarian Society of Scotland*, That he would be a bold man who should now publish an history of Queen MARY, in the same strain with the two historians, (Mr HUME and Dr ROBERTSON), whose opinions on the subject the Enquiry had examined and controverted.

I CANNOT help observing, in justice to Mr HUME's impartiality, that no possible motive could be assigned for the prejudice which the favourers of Queen MARY have supposed him to entertain against her. As a party question, in which view Mr TYTLER has placed it in his *Introduction* to the latter editions of his work*, Mr HUME had surely no bias to mislead him

* "THE character, accomplishments and misfortunes of this Princess, (says the *Introduction*), have been the subject of much writing and controversy among the British historians. Republican writers, equally averse to monarchy and to the House of Stuart, have drawn her picture in the blackest colours, by traducing her as an accomplice with the Earl of BOTHWELL in the murder of the Lord DARNLEY her husband. On the other hand, the writers attached to the ancient constitution of their country, and to the Family of STUART, have regarded that unfortunate Princess as one of the most virtuous and accomplished characters of that age, and as a victim to the secret conspiracies carried on by some of the heads of the reformed party in her kingdom for her destruction."

him in the consideration of it ; and it is a circumstance rather singular, that while he has generally been charged with *Toryism* by one party, he should, on the other hand, be accused by implication of *Republicanism* in this question on the history of the unfortunate Queen of Scots.

Account of
W. Tytler, Esq;

THE other illustrious historian, whose opinions Mr TYTLER controverted in his Enquiry, though of opposite sentiments from Mr TYTLER as an author, lived with him in habits of private friendship and familiar intercourse. The last time Mr TYTLER dined at Dr ROBERTSON's, he saw with peculiar satisfaction HAMILTON's historical picture of Queen MARY, with the portrait of the Doctor on one side, and his own upon the other. Dr ROBERTSON, talking accidentally with the writer of this account on the subject of the *Marian controversy*, said, " I have told Mr TYTLER, that nothing but a regard for what I conceive to be historical truth, could have given my history that complexion which is so different from what he thinks it should have worn. MARY was the natural heroine of my history, if truth had allowed me to make her so."

SUCH would have been the natural vanity of an author ; nor was the national vanity of a Scotsman less interested in the fate of this beautiful and unfortunate Queen, whom her evil destiny transplanted from the sunshine of a gay and gallant court to a barbarous and unfriendly clime ; to a clime, shaken by the storms of faction, and desolated by the furious contentions of a tyrannical and savage aristocracy. It has been matter of regret with some who feel for the Princess in this view of her history, that her advocates have not left her cause to those feelings, but have pushed very far her pretensions to unimpeachable conduct and princely virtues, instead of pleading an apology for error or weakness, from the circumstances of the times and the intricacies of her situation. Even in the pages of ROBERTSON, after all that he has allowed of presumptive evidence for her impru-

Account of
W. Tytler, Esq;

dence or her crimes, the sentiment of the reader, let his historical opinion be ever so adverse to the Queen, prevails over his justice, and the dramatic effect of the story is uniformly, compassion for the Princess, and resentment against her enemies.

To him who looks on that portion of history rather with the eye of a moralist than of an antiquarian, her marriage with BOTHWELL is the most unfavourable passage of her life, both as affecting the propriety of her conduct in that particular, and as tending to corroborate the evidence produced by her enemies on the great charge of privacy in the murder of her husband. Of that marriage, Dr HENRY thus expresses himself, in the letter I mentioned above, written to Mr TYTLER on the 20th of July 1790, a few months before his (Dr HENRY's) death. " Her last marriage (says the Doctor) was the most unhappy, and there seems still to be some difficulty in vindicating her conduct in contracting that marriage. Was she seized by BOTHWELL in her passage from Linlithgow, in consequence of a pre-concert, and with her own consent; or was it by mere violence, and without her having any intimation, that such an attempt was made? If I could answer that question, I should know what to think of several other things."

IN consequence of this letter from Dr HENRY, Mr TYTLER wrote a *Dissertation on the Marriage of Queen MARY with the Earl of BOTHWELL*; which, with the letter that occasioned it, was published, in 1792, in the Transactions of the Antiquarian Society of Scotland, of which Mr TYTLER was one of the Vice-presidents. In this dissertation, he maintains, in conjunction with WHITAKER and STEUART, that the Queen's marriage with BOTHWELL was an object which the treacherous MURRAY and his associates had all along wished to accomplish, and that it was at last brought about by the daring ambition (encouraged by them) of BOTHWELL himself, who, having seized the Queen on her return from visiting her son at Linlithgow, carried her prisoner to Dunbar, where, by the most flagitious and violent

violent means, he first obtained the privilege, and then the legal character of a husband.

Account of
W. Tytler, Esq;

I HAVE placed this *Dissertation* next in order to the *Enquiry*, because both relate to the same historical fact, though in point of time it was the last of Mr TYTLER's compositions. Before that *Dissertation*, he had produced several other works on historical and literary subjects, namely,

I. *The Poetical Remains of JAMES the First, King of Scotland,*

In one volume 8vo, published at Edinburgh in 1783. The volume, of which the above is the general title, contains a *Dissertation* on the Life and Writings of King JAMES the First, one of those Princes, in whose lives, disastrous rather than unfortunate, adversity was the parent of wisdom and of virtue, and was cheered by religion, philosophy, and the muses. This *Dissertation* introduces two well known ancient poems, which Mr TYTLER, on very strong grounds, ascribes to the King, viz. *The King's Quair*, and *Christ's Kirk on the Green*. The poem of *The King's Quair*, or in modern English the King's book, is a very striking proof, not only of the poetical genius and imagination of its author, but of a taste cultivated and refined by an acquaintance with the classical poetry of the ancients, and the works of those eminent bards who were his cotemporaries, CHAUCER, GOWER and LYDGATE. The subject of the poem is the passion of JAMES for his lovely mistress JANE, daughter of the Earl of Somerset, who afterwards became his Queen; and the chief circumstances of the poet's life, the misfortunes of his youth, his long captivity, the incident which gave rise to his love, its purity, constancy, and success, are well described under the quaint, but at that time fashionable figure of poetry, allegorical vision. This work, which is mentioned by JOHN MAJOR as the composition of JAMES, and which in later times had been seen by Bishop TANNER in an ancient MS. among

Account of
W. Tytler, Esq;

the Seldenian archives in the Bodleian library at Oxford, was, in consequence of a diligent search made at Mr TYTLER's instigation, happily recovered, and by him now for the first time given to the public, with explanatory, critical and historical notes. The poem of *Christ's Kirk on the Green* was well known to the public, and had long been admired for its wit and humour; but it had been ascribed, even by antiquarian writers, to JAMES the Fifth of Scotland, the author of *The Gaberlunzie Man*, and other ludicrous compositions. It occurred to Mr TYTLER, that the public was in a twofold error respecting this favourite poem; first, in considering it merely as a *jeu d'esprit*, or fanciful display of the author's imagination and powers in the ludicrous; and secondly, in attributing the composition to JAMES the Fifth. In the Dissertation on the Life of JAMES the First, he has argued, with much ingenuity, that the scope and view of the work was political and patriotic; its end, the best purpose of a Sovereign's writings, the improvement of his people. The English at that time excelled all other nations in the use of the bow. JAMES, on his return to his kingdom, was mortified by the striking inferiority of his own subjects in that particular to their warlike neighbours. The practice of archery, and of *weapon-schawing*, a military exercise, had gone into shameful neglect during the weak administration of the Regents of the kingdom. To remedy this defect, a more regular discipline was enforced by the young Monarch, by statutory regulations; who tried at the same time the efficacy of ridicule in composing this ironical satire (for such, according to the ingenious supposition of Mr TYTLER, is *Christ's Kirk on the Green*) on the awkward management of the bow, and the neglect of archery among the Scots. In the age of JAMES the Fifth, the vulgarly reputed author of the poem, the use of fire-arms had completely superseded the bow as an engine of war. The laws of JAMES the Fifth required, that every man should arm himself with a hackbut or musquet. In that era, therefore, the satire on the
want

want of skill in archery would have been lost or misapplied, its irony no longer felt, its salutary end no more perceived. Besides this argument from the general tenor of the poem, Mr TYTLER has adduced the intrinsic evidence arising from the *language* of the piece, as clearly ascertaining its date to belong to that period to which he has assigned it.

Account of
W. Tytler, Esq;

AT the end of the poem of *Christ's Kirk on the Green*, is a note by Mr TYTLER, in which he pays a just tribute to the worth as well as genius of our celebrated pastoral poet ALLAN RAMSAY, and contradicts, from his own personal knowledge, the absurd story of RAMSAY's not being the author of the well known pastoral drama, *The Gentle Shepherd*.

SUBJOINED to the Dissertation and Poems, is an Essay by Mr TYTLER (first annexed to ARNOT's History of Edinburgh, published in 1788) on the *Scottish music*. This last was very properly included in the volume above mentioned, from its connection with the history of the Prince, whose poems it was the chief purpose of that volume to record and illustrate; the system maintained by Mr TYTLER in this essay on the Scottish music, being, that the style of the ancient melodies of this country was first introduced by King JAMES the First. This was chiefly founded on a passage in the *pensieri diversi* of TASSONI, better known as the author of the celebrated mock-heroic *la secchia rapita*, who, mentioning the musical talents of this Monarch, ascribes to him the "invention of a new kind of music, plaintive and melancholy," which Mr TYTLER, in this essay, supposes was the original of those beautiful and pathetic airs which are known and distinguished as the national music of Scotland.

II. Obser-

Account of
W. Tytler, Esq;

II. *Observations on the VISION, a Poem first published in RAMSAY'S Evergreen.*

These observations, which vindicate ALLAN RAMSAY'S title to the poems in question, were published in the before-mentioned volume of the Antiquarian Transactions in 1792.

III. *An Account of the fashionable Amusements and Entertainments of Edinburgh in the last Century, with the Plan of a grand Concert of Music [performed there] on St Cecilia's Day 1695.*

MR TYTLER was likewise the author of a paper in the *Lounger*, No. 16. "*Defects of modern Female Education in teaching the Duties of a Wife.*"

ON all Mr TYTLER'S compositions the character of the *Man* is strongly impressed, which never, as in some other instances, is in the smallest degree contradicted by or at variance with the character of the *Author*. He wrote what he felt, on subjects which he felt, on subjects relating to his native country, to the arts which he loved, to the times which he revered. A zealous Scotsman, a keen musician, an old man with his youthful remembrances warm in his mind, he wrote on the history of Scotland, on music, and on the amusements of former times in Edinburgh; and I confess, that from a knowledge of this circumstance, I read his works with an interest which I should not feel, if I considered them as flowing from a pen which was the instrument of the author's ingenuity rather than of his heart.

HIS heart indeed was in every thing he wrote, or said, or did. He had, as his family and friends could warmly attest, all the kindness of benevolence: he had its anger too; for benevolence is often the parent of anger. There was nothing
neutral

neutral or indifferent about Mr TYTLER. In philosophy and in history, he could not bear the coldness, or what some might call the temperance of scepticism; and what he firmly believed, it was his disposition keenly to urge.

Account of
W. Tytler, Esq;

His mind was strongly impressed by sentiments of religion. His piety was fervent and habitual. He believed in the doctrine of a particular providence, superintending all the actions of individuals, as well as the great operations of nature; and he had a constant impression of the power, the wisdom, and the benevolence of the Supreme Being.

His reading was various and extensive. There was scarcely a subject of literature or taste, and few even of science, that had not at times engaged his attention. In history he was deeply versed; and what he had read his strong retentive memory enabled him easily to recal. Ancient as well as modern story was familiar to him, and in particular the British history, which he had read with the most minute and critical attention. Of this, besides what he has given to the public, a great number of notes which he left in MS. touching many controverted points in English and Scottish history, afford the most ample proof.

IN music as a science he was uncommonly skilled. It was his favourite amusement; and with that natural partiality which all entertain for their favourite objects, he was apt to assign to it a degree of moral importance which some might deem a little whimsical. He has often been heard to say, that he never knew a good taste in music associated with a malevolent heart; and being asked, what prescription he would recommend for attaining an old age as healthful and happy as his own? "My prescription, said he, is simple: short but cheerful meals, music, and a good conscience." In his younger days, he had been a good performer on the harpsichord; but his chief instrument was the German-flute, which he thought peculiarly adapted to the expression of those natural and simple melodies in which

Account of
W. Tytler, Esq;

which he most delighted, the Scottish airs. He was one of the original members of the *Musical Society of Edinburgh*, in which he continued, during a period of near sixty years, till his death ; during the greatest part of which time, he was a Director of that Society, and felt for its permanence and prosperity that warm and lively interest, which animated him alike in business, in study, and in amusement.

IN person, Mr TYTLER was rather thin, and somewhat below the middle size. His walk, even at the latest period of his life, was of that quick and springy sort which accorded with the activity of his mind. In his youth, he was fond of manly exercises, and often talked with regret of those which the gentlemen of Scotland had lost in the refinement or effeminacy of modern times.

ENDOWED with so many qualities adapted for friendship, Mr TYTLER had many friends, and among these were some of the most distinguished literary characters of the age. In that number were the late Dr JOHN GREGORY, Principal CAMPBELL and Dr GERARD of Aberdeen, Dr REID, Dr BEATTIE, Lord KAMES, and Lord MONBODDO. A man who lives so long must necessarily lose much of his cotemporary society ; but the loss was compensated to him more than it generally is to persons of his age, by that interest which he took in the conversation and in the amusements of the younger people who were the acquaintance or companions of his children.

HE was indeed of a temper remarkably social, and found, from the congenial ardour of his own mind, particular delight in the company of young people ; to whom, from the store of anecdotes he possessed regarding the incidents, the manners, and the habits of former times, his conversation was equally instructive and entertaining. He was, however, one of those fortunate praisers of times past who are perfectly alive to the enjoyment of the present ; whose partial recollection of former times and former joys results from the same warm and active temperament,

temperament that still preserves cordiality for present friends and spirit for present amusements. He retained this ardour and activity to the close of life; and at fourscore, was as ready as ever to join in the conversation, to participate the mirth, even to enter into the innocent convivial frolic of his young friends and relations. At his country-seat of *Woodhouselee*, distant about six miles from Edinburgh, where he saw them with peculiar satisfaction, he had erected in a private and sombre walk, an urn, with this inscription:

Account of
W. Tytler, Esq;

Hunc lucum
Caris mortuis amicis
Sacrum dicat
W. T.

Yet from this walk, from the indulgence of the remembrance and regrets which it inspired, he would return to the social circle within, with unbroken spirits and unabated cheerfulness.

IN domestic life, Mr TYTLER's character was particularly amiable and praise-worthy. He was one of the kindest husbands and most affectionate fathers. At the beginning of this account, I mentioned his having lost, at an advanced period of life, an excellent wife, and a son and daughter both grown to maturity, who merited and possessed his warmest affections. The temper of mind with which he bore those losses, he has himself expressed in a MS. note, written not long before his death; with which, as it conveys a sentiment equally important in the consideration of this life, and in the contemplation of that which is to come, I shall conclude the present Memoir: "The lenient hand of time, (says Mr TYTLER, after mentioning the death of his wife and children), the lenient hand of time, the affectionate care of my remaining children, and the duty which calls on my exertions for them, have by degrees restored me to

Account of
W. Tytler, Esq;

myself. The memory of those dear objects gone before me, and the soothing hope that we shall soon meet again, is now the source of extreme pleasure to me. In my retired walks in the country I am never alone; those dear shades are my constant companions! Thus, what I looked upon as a bitter calamity, is now become to me the chief pleasure in life."

III.

For from this work, from the indulgence of the friends, the regrets which it inspired, he would return to the world, with broken spirits and unsteady equilibrium. His domestic life, Mr. Tytler's character was particularly amiable and praiseworthy. He was one of the kindest husbands and most affectionate fathers. At the beginning of this account I mentioned his having left, at an advanced period of life, an excellent wife and a son and daughter both grown to maturity, who married and possessed his warmest affections. The number of mind with which he bore those losses, he has himself expressed in a MS. note, written not long before his death; with which, as it conveys a sentiment equally important in the contemplation of this life, and in the contemplation of that which is to come, I shall conclude the present Memoir: "The remembrance of time (Mr. Tytler, after mentioning the death of his wife and children), the present hand of time, the separate care of my remaining children, and the duty which calls on my exertions for them, have by degrees returned me to my former state of mind."

(E)

Vol. IV.

III. *A BIOGRAPHICAL ACCOUNT of Mr WILLIAM HAMILTON,*
late Professor of Anatomy and Botany in the University of
Glasgow. By ROBERT CLEGHORN, M. D. F. R. S. EDIN.
Lecturer in Chemistry in the University of Glasgow.

[Read 6th Nov. 1792.]

IN writing the life of a person who himself published nothing, it is extremely difficult to satisfy the expectation of his particular friends, without incurring the charge of adulation from the rest of the public. How far I have succeeded in doing justice to Mr HAMILTON's merit, without insensibility or exaggeration, must be determined by those who knew him, and by those who can appreciate the worth of such professional remarks as I shall lay before them in the sequel. Mr WILLIAM HAMILTON was born in Glasgow July 31. 1758*. Having finished the usual course at the Grammar School, he went to Glasgow College in 1770, and continued there studying with great diligence till 1775, when he became Master of Arts at the age of seventeen.

(E 2)

HAVING

* His father was Mr THOMAS HAMILTON, an eminent surgeon, and professor of anatomy and botany in Glasgow; his mother Mrs ISABEL ANDERSON, daughter of Mr ANDERSON, formerly professor of church-history in the University of Glasgow.

Account of
W. Hamilton

HAVING shewn an early and strong predilection for the study of physic, he went to Edinburgh, which was then, as it is still, the most celebrated school of medicine in Europe. During the summer of 1775, he studied botany under the late worthy Dr HOPE; and during the two ensuing winters he studied with great ardour under all the medical professors, and enjoyed the friendship of Dr CULLEN and Dr BLACK, who having been formerly members of the College of Glasgow, were the companions and friends of his father.

Mr HAMILTON intended to have remained a third season in Edinburgh, but the state of his father's health rendered it necessary for him to give up this plan. Accordingly, in summer 1777, he accompanied his father to BATH, and from thence to London, where he was recommended to the particular notice of the late Dr WILLIAM HUNTER, and of his brother Mr JOHN HUNTER. Each of these gentlemen was connected with Mr T. HAMILTON by early friendship, and a constant intercourse of good offices. Under their direction Mr HAMILTON quickly distinguished himself by that ardent pursuit of anatomical and professional knowledge, which marked every part of his subsequent life. Though left at an early age to his own conduct, in a city abounding above all others with objects of pleasure and amusement, he resisted the blandishments of both, devoting his time to the acquisition of knowledge, applying not only to those parts of study which were entertaining, but to those also which the young are apt to neglect as uninteresting, or to despise as useless, and manifesting, on every occasion, a diligence discouraged by no difficulty, and interrupted by few avocations.

SUCH conduct did not escape the eye of Dr HUNTER. Indefatigable himself, he was delighted with appearances of professional zeal among his students; and he was so particularly pleased with them in the son of his old friend, that, after the first season, he invited Mr HAMILTON to live in his house, and committed the dis-
lecting-

Account of
W. Hamilton.

secting-room to his care. In this situation, the best that a student of anatomy could wish for, Mr HAMILTON continued two years hearing the lectures, and enjoying the conversation, of the first anatomist in London. How far, in Dr HUNTER's opinion, he improved this opportunity, appears from the following letter addressed to Mr T. HAMILTON, December 31. 1778: "Your son makes me very happy on your account, and for his own sake. I see and hear much of him; and every body regards him as sensible, diligent, sober, and of amiable dispositions. He is now in the direct road for acquiring knowledge, as director in the dissecting-room. It obliges him to apply, because he is to answer any question, and solve any difficulty that may occur; and which is best of all, he is to demonstrate all parts of the body again and again to students. This is a most instructive province, and a fine introduction to giving lectures, as it gives facility in public speaking, and a habit of demonstrating distinctly and clearly, both of which are easily acquired while we are young; and yet, for want of that very opportunity, are possessed by few. In this way he will acquire not only knowledge, but a character for knowledge with the public, which a young man cannot procure but by being in some public station."

In another letter to the same gentleman, dated May 18. 1780, Dr HUNTER says: "Your son has been doing every thing you could wish, and from his own behaviour, has profited more for the time than any young man I ever knew. From being a favourite with every body, he has commanded every opportunity for improvement which this great town afforded during his stay here; for every body has been eager to oblige and encourage him. I can depend so much on him, in every way, that if any opportunity should offer for serving him, whatever may be in my power I shall consider as doing a real pleasure to myself."

THE

Account of
W. Hamilton.

THE opportunity hinted at soon occurred. Mr HAMILTON came to Glasgow in 1780, and taught for his father during the ensuing winter. Having given most satisfying proofs of knowledge in anatomy, and of talents as a lecturer, he was appointed in 1781 successor to his father, who had resigned some time before. When consulted about this appointment, Dr HUNTER said to the Marquis of GRAHAM, now Duke of MONTROSE, "That from an intimate knowledge of Mr HAMILTON, as a man, and as an anatomist, he thought him every thing that could be wished for in a successor to his father, and that it was the interest of Glasgow to *give him*, rather than his to solicit the appointment."

His father lived till January 1782; but the whole burden of lecturing, and the greatest part of the business, devolved on the son. The business was very extensive, as old Mr HAMILTON was connected with many of the most respectable families in Glasgow and its neighbourhood. His professional character, too, was high as a successful practitioner, and a skilful operator; and being withal a man of great hilarity, and genuine humour, his company was courted by all who relished wit and good fellowship. From the co-operation of so many favourable circumstances, Mr HAMILTON's progress was extremely rapid, his outset being encumbered with few of those difficulties, which have often obstructed the course of other young practitioners. His father lived long enough to introduce him fully. His youth did not diminish the confidence of his patients; because, besides knowing that he had studied with uncommon care, in situations the most favourable for acquiring knowledge, they believed that he had ready access at all times to the experience of his father. By gentleness of manners, by unaffected benevolence, by the most prudent circumspection in all his conduct, and by unremitting attention to his patients, he not only retained most of those who had employed his father, but added many

many to the number. While he practised extensively as a surgeon, his skill in anatomy made him be consulted by many surgeons, older than himself, before they performed operations; and, in a few years, those who had been his pupils, practising in distant parts of the country, consulted him on similar occasions. Besides anatomy, he taught botany and midwifery; which last he practised with such success, that he was called to almost every difficult case near Glasgow. In October 1783, he married Miss ELIZABETH STIRLING, an accomplished lady, connected with several opulent families in Glasgow and its neighbourhood. From these connections, his practice, already extensive, was very considerably increased.

ANXIOUS to excel, not only as a skilful physician, and an expert surgeon, but as a public teacher, he was led to consider every case that he treated more accurately than is usually done by those who confine their attention to practice merely. Though naturally convivial, and endowed with a considerable degree of his father's humour, he avoided company as much as he could with prudence, and devoted every vacant hour to study, and especially to writing. He kept a regular account of all uncommon cases, accompanying the conclusion of each with remarks suggested at the moment, and forming, at the end of each year, a general table of the diseases which had prevailed during the different seasons. This plan facilitated his practice, and was highly gratifying to his patients, by convincing them, that their former complaints were distinctly remembered: But he had a higher object in view than the assisting of his own memory, or the gratifying of particular patients. His object was to have published a System of Surgery, illustrated with cases, of which several are fully and accurately drawn up. As a specimen of what might have been expected from this work, had he lived to finish it, I shall mention a few particulars, which, on account of their

Account of
W. Hamilton.

their novelty or importance, seem most worthy of being recorded.

UPON performing lithotomy for the first time, he was struck with the difficulty of introducing the gorget, and, on examination, he found it blunt at the point, where sharpness was most needed, so that instead of cutting, it tore the urethra. The cutter finding it difficult to sharpen the gorget, as commonly made, up to the button which goes into the staff, Mr HAMILTON directed him to make it in two separate pieces, which, locking together, had all the firmness of the old instrument, with the advantage of being easily sharpened when taken asunder. This instrument he always employed afterwards in operating, which he did often, and with great success.

IN midwifery he met with several uncommon cases, of which the most remarkable are instances of two women who survived a complete inversion of the womb*. He detailed those cases to his pupils, along with others that ended fatally; and took occasion from them all to enforce the necessity of avoiding force, or even haste, in delivering women. The following extract, nearly in his own words, proves with what caution he treated his patients, and with what care he considered their cases afterwards: "I have seen four cases of inverted uterus, of which two patients died, and two recovered. This recovery is so singular, that I know only one case by THOMAS BARTHOLINUS similar to it.

"THE great object in all cases of such danger, is to understand fully how the accident happens, that so we may be able to prevent its occurrence. It is evident, that the uterus can never be inverted when it is contracted, or even beginning to contract itself; it therefore must happen when the fibres of it are relaxed,

* BOTH these patients are still alive; and the history of one is given in the Medical Communications of London, vol. 2.

relaxed, allowing themselves to be bent in any direction, and when the uterus is still large. This is the condition of the uterus; when the child has been forced away, either by the action merely of the abdominal muscles and diaphragm, or by the assistance, as it is called, of the midwife, should the placenta adhere to the very fundus or near it, a small degree of force, applied to the cord, may invert the uterus while large, flaccid, and empty.

“THE surest method of preventing such an accident, then, is to produce a complete and regular contraction of the uterus, which may be accomplished more easily than some have imagined. For we know, that as long as any stimulus is applied to the cavity, and especially to the mouth, which is the most irritable part of the womb, a contraction will take place, in order to expel the stimulating cause. Therefore, by allowing the child to be born solely by the pains of labour, by giving no assistance in the extraction, (except where the size of the child, or the mal-conformation of the pelvis, render assistance absolutely necessary), and by preventing the delivery of the body from being accomplished by the abdominal muscles solely, we force the uterus to contract itself, and to expel its contents. After the delivery of the body, by allowing the legs to lie for a short time in the vagina, and to press on the mouth of the womb, we ensure its contraction.

“By such management, the uterus having been made to contract itself properly, we have the placenta separated, and ready for extraction. Thus, together with the danger of inversion, we are freed from two more common accidents, *viz.* a retained placenta and a flooding. Besides, the child is less hurt, when the slow delivery allows time for the dilatation of the passage; and it runs no risk of those sprains and bruises which often happen in attempting to pull away the child without the assistance of a labour-pain.

Account of
W. Hamilton.

" I HAVE paid particular attention to this subject, and I have always found, that where the womb was inverted, where the placenta was retained, or where much flooding followed the birth, the child had been born, head and body at once, by a single pain. An attention to this point, procured Dr HUNTER part of the fame which he so justly possessed, on account of his skill and caution in midwifery. He has often told me, that many women had been under his care, who, with other practitioners, had lost much blood, and been exposed to much danger, from the speedy extraction of the after birth. By allowing it to separate slowly from the uterus, and after separation to lie for half an hour in the vagina, he completely avoided the flooding, and the danger that attends it."

MR HAMILTON was called to many cases of luxation, both of the shoulder and thigh joint; in reducing which, he succeeded by very simple means, after other surgeons, who employed the force of machinery, had failed. On this subject he wrote an accurate paper; in which, after describing the joints, with the ligaments and muscles that surround them in a natural state, he considers fully the change brought on every part by luxation, deducing partly from the structure of the parts, chiefly from his own extensive experience, the following directions concerning the best mode of reducing the joint to its natural position:

" THE situation of the muscles round the joint differs much according to the kind of dislocation.

" IN all cases the deltoid is stretched, but particularly when the bone is thrown directly downwards. The long head of the biceps must be sometimes torn, but, where it is not, it will be extended, and the ligament through which it passes, and which binds it to the humerus, will be always lacerated in a greater or less degree. The muscles that are most deranged, are the supraspinatus, subscapularis, and infraspinatus. These two last we shall call the lateral muscles of the joint.

" IN

" IN the dislocation downwards the supraspinatus will be on the stretch, the subscapularis and infraspinatus will have their fibres lengthened, and their direction altered, in consequence of the head of the humerus being thrown below the glenoid cavity.

" WHEN the bone is dislocated outwards, and rests on the dorsum scapulæ, the situation of the muscles will be nearly the following: The subscapularis and supraspinatus will be both very much stretched, while the infraspinatus, having the humerus thrown under it, will be relaxed, and a number of its fibres will be torn from the scapula, to make room for the head of the bone.

" IN the third situation, when the bone is luxated inwards, the supraspinatus and infraspinatus will be on the stretch, while the subscapularis will be relaxed, and in the same situation as its opposite muscle has been described in the preceding species of dislocation.

" THIS account is drawn from the natural situation of the parts, and the few cases of dislocation where there has been an opportunity of dissecting the arm. It may be observed, that in all the three species of luxation, the supraspinatus and deltoid are put much upon the stretch, the last in a less degree. From this we may infer the propriety of relaxing these muscles completely during the time of reduction; and this is another reason for raising the arm when we attempt to replace the bone.

" MR THOMSON * speaks of the head of the humerus being caught between the tendons of the infraspinatus and teres minor, as in a noose; this can happen only in the luxation outwards, and is one reason for relaxing them completely in attempting reduction, by throwing the arm towards the side of the scapula, opposite to that where the head of the bone is lying. Having mentioned the situation of the muscles, I shall now

(F 2)

point

* London Medical Observations, vol. 2. p. 354.

Account of
W. Hamilton.

point out the changes that take place on the joint, when left unreduced, as being our proper guide in judging what line of practice is to be followed in such cases. An unreduced luxation may be described in three situations: The first, when the parts are little changed from the state they are in, immediately after dislocation happens. The second, where motion is beginning to take place, and when the soft parts become adapted to the dislocated state of the bones. And the last, when a new joint is formed. After the head of the bone is lodged on some part of the scapula, it is found to consolidate the cellular membrane and muscular fibres under it, so as to form a kind of soft socket for itself, which, by the pressure of the cartilage on the end of the humerus, and by the motion the arm admits of, gets a smooth surface. The bursal ligament torn on that side next the humerus, is pulled across the glenoid cavity, and the muscles will be found in the state I have already described.

“AFTER the inflammation and swelling, consequent upon the injury, have gone off, the patient will be plagued with pains in the stretched muscles, and will be incapable of moving the joint with ease. The inflammation will however make the lacerated parts grow together, so as to obliterate the passage through which the head of the bone escaped from the joint. This may be reckoned a luxation in a recent state. After some time the muscles begin to adapt themselves to the state of the bones, those that were overstretched are lengthened, and the relaxed ones contract, so that the person is capable of moving his arm, and by degrees the motion becomes more considerable. The bursal ligament now gets adhesions to the edges of the glenoid cavity, over which it lies, and the opening in it, through which the bone passed, is filled up, so that it embraces the humerus closely. The torn passage in the soft parts has become as firm as if no laceration had ever take place. The socket, formed in the cellular substance, between the head of the humerus and the scapula,

scapula, begins now to be removed, from the constant pressure made upon it; and before this, which we would call the second state of the dislocation, is completed, that bone is resting on the surface of the scapula itself. It is much to be wished, that it were ascertained, by accurate observations, when these changes take place, and particularly when the third state, which we are next to describe, begins. This last state of a dislocation is, when nature is beginning to form a new joint to supply the place of the old one.

"THE soft socket having been completely removed, the humerus is resting on the surface of the scapula. By pressure, and frequent motion, a cavity is formed for the head of the bone; the surface of this new cavity becomes smooth, and is covered with a cartilaginous crust; the attachment of the humerus to the parts around answers the purpose, and at last assumes the appearance of a ligament, so that a new joint may be said to be formed completely in all its parts. That this can happen, has been proved by dissection; and particularly in a man, after whose death my father had an opportunity of examining his arm, which had been dislocated for upwards of thirty years. This person was a fencing-master, and, as it was his right arm, he was obliged to perform with it a great variety of motions. He had acquired so completely the use of it, that he could perform all the different motions necessary in the small sword, except pushing a high carte*.

"MONSIEUR MOREAU † gives two cases similar to this, of old luxations of the thigh, where the head of the femur had formed a new acetabulum for itself in the os innominatum. Another case, though not of a dislocated shoulder, I shall likewise describe.

* MR THOMSON dissected a man with a new socket, formed in the inside of the scapula, Med. Obs. vol. 2.

† MEMOIRES de l'Academie de Chirurgie, tome v. p. 45, small edition.

Account of
W. Hamilton.

scribe, as illustrating the efforts of nature, to supply the motion between bones after dislocation, and where a process for forming a new joint, that, so far as I know, has never been described, is taking place. The bones are from a woman, who was dissected in the theatre here, about four years ago; the thigh had been long dislocated, and the woman had been able to walk about. The neck of the os femoris lay on the edge of the acetabulum, while the head, which is changed in its shape from the pressure of the surrounding parts, was on the dorsum ilii beyond this cavity. The edge of the acetabulum filled up the hollow at the neck of the femur, which is made deeper by its pressure. There are two processes of bone growing into the acetabulum from the os femoris, and which at last would have formed a kind of head to play in this the cavity of the old joint, and thus have made a new one considerably different from that in the cases already mentioned. By one or other of these different ways, nature attempts to remedy the injury done to a limb after luxation. At the time the head of the humerus is forming a new socket for itself, the glenoid cavity is destroyed, its sides approach each other, and the hollowed part is filled up by granulations of bone. The bursal ligament adheres to the surface of this cavity, and is thus to all appearance lost.

“THE patient continues in this state, with a joint either more or less perfect, and, when proper attention has been paid, the new joint may be made a very useful one; and to this point alone our treatment of old dislocations ought to be directed. The treatment of luxations must differ according to the state of the disease. When they are recent, reduction in the easiest and safest manner is the surgeon's object: And here we shall make a few observations, drawn partly from what we have already shown to be the state of the joint and muscles, and partly from experience.

“THE head of the humerus being in all cases pulled beyond the glenoid cavity, and lodged on the scapula, the first step towards

wards replacing it, must be to draw it out, so as to bring it over that cavity out of which it was thrown.

" THIS is to be done by making the extension of the arm, with such a degree of force as to separate the bones from each other, and so applied that it may act only upon the parts round the dislocated joint. When extension is omitted, as was the case among the old surgeons, the attempts made by the lever to force the humerus into its place, so far from having salutary, were attended with very bad, consequences. Extension, however, in the modern practice, is our first view. The resistance to the extension is owing to the contraction of the surrounding muscles, which is partly voluntary, and partly the effect of their being much stretched, from the new situation of the bone. The first it is seldom in our power to prevent, as the terror of reduction, and the uneasiness consequent upon moving the arm, makes the patient exert his muscles to resist what gives him pain; and so far as no resolution in him can prevent this action, it may be said to be involuntary. Were it possible to deceive him, and make him suppose we were only examining the state of his arm, when we were really making the proper extension, this cause of difficulty might be overcome in some degree. The resistance from the overstretched muscles is of more importance, as it is in our power to prevent it, and, when not attended to, must increase the surgeon's difficulty, and by extending the muscles, already too much on the stretch, may produce greater laceration than from the disease intended to be remedied.

" THE observations we have already made on the state of the muscle after dislocation, must now appear necessary, being on a subject little attended to, though of great importance, and particularly as they lead us to place our patient in such a manner as to remove this cause of difficulty and danger.

" ANOTHER cause preventing reduction, is the bone being pulled in such a direction by the surgeon, as not to pass through
the

Account of
W. Hamilton.

the cavity it formed for itself in dislocation, but is made to press on the surrounding parts, so that if the force is continued to be exerted in the same direction, a new passage must be torn for it. This, like the last, may be avoided, by attending to the most probable position of the limb when the accident happened. We have attempted to prove, that, in general, dislocation is most apt to happen when the arm is raised; and therefore that this position is the preferable one for reduction. I suspect in many cases, where improper attempts to reduce the bone have been made, that the difficulty is increased by the bone tearing a passage for itself in a new direction, and thus, by twisting the muscles, preventing reduction from being accomplished.

"THE last obstacle is from the burfal ligament. As in no case of dislocation the head of the bone can pass out without lacerating it, so, in reduction, it cannot be replaced, unless it is brought through the same opening by which it went out; for if we attempt to bring the humerus over the glenoid cavity in a wrong direction, the ligament will get between it and the scapula, and thus, when apparently reduced, the bone will return to its old situation, as soon as the arm is let loose. This can be avoided only by the posture of the limb; and here also, in the raised state of the arm, the bone will return most readily through the opening in the ligament, as being put into the same position in which it was luxated.

"THESE three great difficulties in reduction, then, are to be remedied by a proper position of the patient and of his arm; and this, I think, there can be no doubt, is by placing him so, that the extension may be made when his arm is raised. In order to this, I make him sit on the ground, the scapula, with the glenoid cavity upwards, being kept fixed by two assistants who are placed behind him. I put a towel round the humerus, immediately above the elbow, both to give me a firmer hold of the part, and likewise, that, if necessary, I may have a place for an assistant

or

or two in the extension to lay hold by. The fore arm is bent up, so as to relax the biceps completely; and this I prefer to the state of half flexion, as the extensor triceps is not one of the muscles that gives any difficulty in reduction. When the bone is luxated directly downwards, I make the extension standing opposite to the patient's side; but, when it is either outwards or inwards, I place myself towards that side, opposite to where the head of the bone is lying, and I carry the arm in the same direction. If, for example, the head of the humerus is under the pectoral muscle, I carry the arm outwards towards the patient's back, and *vice versa*.

" I THEN begin to make the extension with a slow and steady force, but of such a kind as I find is capable of overcoming the resistance of the muscles, and of bringing the bone out of its place. After it is completely disengaged, it is pulled into the glenoid cavity by the action of the surrounding muscles, so as not to require any pressure in the axilla to raise it up. In this manner I have reduced several dislocations of the shoulder; and in none have I failed, or been obliged to use the force I have seen applied in other modes of reduction, and without effect. Among the cases I have succeeded in, there were seven where all the other methods had been tried in vain; and in three of these the arm had been out for three weeks. Mr WHITE of Manchester* has employed a mode of reduction similar to this, as to the position of the arm; but I think the other parts of his plan are not equal to that here described. The raised state of the arm is likewise advised by Mr THOMSON, from the situation he found the muscles in the dissection of two men with dislocated humeri, who had died before reduction had been effected.

" IN this manner of reduction, all the extended muscles are relaxed by the arm being raised; the supraspinatus and deltoid

(G) in

* Medical Observations, vol. 2. p. 373.

Account of
W. Hamilton.

in the dislocation downwards; and in that to the side, by turning the humerus towards the side of the scapula, opposite to that on which its head is lodged, the lateral muscle is taken off the stretch it was put into by the dislocation. When these over-stretched muscles are thus attended to, the reduction becomes more easy to the surgeon, and much less hazardous to the patient, as laceration is guarded against.

“ AFTER long and violent attempts to reduce the shoulder, particularly with the muscles on the stretch, I have heard of the bone becoming so loose, that when it had been at last got into its socket, it fell out again very readily. This I imagine must have been owing to the muscles round the joint, and the ligament, having been very completely torn, so that the humerus had lost its natural support. In the two modes of reduction most commonly made use of, the state of the muscles is not enough attended to. When the arm is at an acute angle with the side, as when we attempt to force in the bone with the heel in the axilla, the superior muscles are very much on the stretch; and when the patient is placed on a chair, and the arm forms a right angle with the body, they are still not sufficiently relaxed to prevent additional difficulty and danger; and I must agree with Mr THOMSON in thinking attempts in these directions often the cause of succeeding bad consequences. Another advantage of reduction with the raised arm is, that as soon as the humerus is disengaged from the scapula, the muscles, that from the nature of the dislocation were most extended, contracting, pull it into its socket. In other modes of reduction, a considerable force is required to press the bone into its place, after the arm is fully extended. When this force is great, the parts that lie over the bone must be bruised, particularly if a hard body is used to effect this purpose. On this account the *Ambe*, both of FREACK and PETIT, appears to me a bad instrument. It pulls out the arm at right angles, and therefore it requires considerable ac-
tion

tion of the end of the instrument as a lever to force the humerus into its place, while the pressure on the patient's side is equal to the force of the extension. It can likewise be properly used only in the dislocation downwards.

" IN all dislocations of the humerus, the extension, I think, should be made with the hands, in place of pulleys, as by the first, the direction of the bone can be better adapted to the resistance and situation of the surrounding parts.

" IN what we called the second state of an unreduced dislocation, the obstacles are more numerous than in the recent. The muscles have now adapted themselves to the situation of the bones, the hole in the ligament is in part grown up, and the lacerated passage in the soft parts is obliterated, the sides of it having, by inflammation, adhered to each other. These being added to the difficulties in recent luxations, render the reduction here both more difficult, and more apt to be attended with laceration, than in the other. These obstacles are to be got over, however, by the same means. The patient ought to be put into the same position, and the extension made in the same manner, only it will require the force to be greater, and to be longer continued, before it accomplishes the end in view. I do not think, however, it will be necessary to employ any other method, (as that of Mr WHITE), as every thing may be done by the hand, that can be expected from pulleys.

" IN the last state, and even in the latter part of the second, instead of reduction, we should attempt to render the new joint that is forming as perfect as possible. This is to be done principally by making the patient use his arm as often, and for as long a time as he can, without pain or fatigue, and to perform with it a variety of motions.

" IN this way we will hasten the formation of the new joint, and render him sooner capable of using his arm. That this is possible is evident from the case of the fencing-master already

Account of
W. Hamilton.

mentioned, who followed his profession for upwards of five and twenty years before his death, and who, by being obliged to use his arm, acquired the motion of the new joint sooner than if he had been under no such necessity.

"IT is a matter of importance to ascertain when the changes, we have described, take place. I imagine the recent state may continue for a fortnight or three weeks: But still we want observations to point out when the muscles become completely adapted to the new situation of the bones; when the glenoid cavity begins to lose its shape, and the ligament to adhere to it; and, particularly, when the surface of the scapula begins to become hollowed and smooth, so as to receive the head of the humerus. These, however, may be guessed at, by the quality and degree of motion enjoyed in the dislocated joint. Were these points fully ascertained, they would guide us in our practice, and prevent attempts being made to reduce old dislocations, where the surgeon, from want of knowledge of the process carrying on by nature to form a new joint, and the obliteration of the old cavity, racks the patient's limbs to no purpose; and even should he be successful, he might be said not to reduce, but really to dislocate, as he destroys a new joint beginning to enjoy motion, and throws the end of the bone on a surface which has now lost every thing necessary to make it a part of a joint."

MR HAMILTON had occasion once to open the chest of a *Lady*, who had water in her breast. The quantity at first drawn off amounted to sixteen ounces; a great deal oozed out afterwards, and some of the symptoms were for a little relieved, but the patient died in a few weeks. On the best manner of performing this operation, he makes the following remarks:

"IN Mr BELL's mode of operating, which I here followed, simply drawing off the water, and avoiding every thing that may bring on inflammation on the cavity, is not sufficiently kept in view. An extraneous body, a canula, is introduced and kept in

for

for two or three days. The effect of this practice is evident; inflammation may be brought on over the cavity; suppuration will succeed, and the case will be converted into one of empyema, with an opening in the chest. The effects of keeping in a canula in the abdomen were found, by the old surgeons, to be so bad, that the practice was given up, even before the faintness, from drawing off the water at once, was so well understood as to be capable of being prevented. In our patient, symptoms of inflammation from the canula were beginning when it was withdrawn, and had it been kept in another day, the inflammation would probably have become so considerable, that it might have been expected to produce the worst consequences.

"THE view with which a canula is introduced and kept in, is, to allow the water to run off only when we choose it, and to prevent air from getting into the cavity. The first intention it does not answer; as in our patient, though it was introduced through the pleura when only a small perforation had been made in it, so that it might be closely embraced, the water oozed out by its sides, and more was discharged in this way than by the canula itself.

"AIR is likewise more apt to get into the cavity by the canula, than if the water was discharged without it. It is impossible to stop it so accurately and quickly with the finger or cork, as to prevent the access of air, when there is little water left, or when the lungs are not in a situation to fill the cavity, and especially when the patient is inspiring. This I found to be the case, when I drew off the last water by it. But before I left the patient, I evacuated the air as completely as possible, by depressing that side of the chest during expiration.

"FROM the structure of the thorax, air is apt to be drawn in by the external wound, and is again not easily expelled. The most ready method of evacuating it, is by compressing that side
of

Account of
W. Hamilton.

of the chest during expiration, at the same time pressing up the viscera of the abdomen, so as to make the diaphragm ascend; and thus, by lessening the cavity, while the patient, by shutting the glottis, prevents the air from escaping, but forces it into the collapsed lung, we force out as much of it as possible. Other ways of evacuating it hath been suggested by different writers. Sucking it out by a syringe, or an elastic bottle, are common proposals, but I am afraid can never be put in practice. The bottom of the wound between the ribs is so irregular, that they can never be applied when the canula is out; and when it is in, more air would be admitted during the time the syringe, or bottle, was fitting on, than could be extracted by them. But after all the water is evacuated, the wound must be healed up, for if not, suppuration will come on the wound, and when the canula is then withdrawn, the skin, that was intended to act as a valve, will have become fixed by the inflammation, and will not come down over the hole in the pleura, so that air must be admitted, though it was excluded before.

“ WHETHER common air does hurt to any cavity, I doubt much. Water, with a penetrating wound, would be as bad. The inflammation of the wound is what is most to be dreaded, as it spreads from that over the whole cavity. The canula, therefore, as inducing inflammation, must, in my opinion, be very hurtful.

“ IN place of the operation described by Mr BELL, I would propose doing it in the following manner: I would place my patient in the common posture, and, after the skin was well pulled up, make my incision in the usual place and manner, till I came down to the pleura. I would then make an opening through it, about half an inch in length, merely dividing the membrane. In cutting into the cavity, great care should be taken not to do it rashly, lest an adhesion of the lungs to the pleura be over the incision. At the same time we must expect to find the

the pleura much thicker than it naturally is, owing to the effects of inflammation, and the pressure of the water, so that a timid operator, not aware of this circumstance, (which is not taken notice of), might desist, from an idea of having met with an adhesion, when he was really only half way through the membrane. In a case of hydrothorax I opened, I found the *pleura costalis* a fifth of an inch thick. I would then allow as much water to run off as I thought proper, two assistants making such a degree of pressure on the ribs of that side as to prevent their being raised in breathing, during the time the fluid was discharged. After I had drawn off such a quantity as flowed readily, and the patient could bear without faintness, I would bring the loose skin over the hole in the pleura, and fix it there with slips of emplastr. adhesiv.; I would then lay the patient on the diseased side, so as to allow the water to ooze off by the wound, while air would be prevented from getting in, by the skin acting as a valve. If the patient grew faint, from the evacuation being too quick, it could easily be lessened, or stopped, by making him turn more and more towards his back, or opposite side, so as to make the hole in the pleura less a depending opening; or, by making pressure upon the skin over the opening, the discharge might be completely stopped. If the lung was not diseased, as the water flowed off, it would be more and more filled with air, and expanded. If it was so much diseased as to be incapable of expansion, by no mode of operation can more water be drawn off than what distended the cavity; a quantity must be left equal to the want of enlargement of the lung; if we draw off more than this, air must supply its place; for we are not to imagine we can take away all the water, and leave a vacuum. The wound will admit of the water oozing long enough to evacuate all that should be taken away; and it will not be prevented from healing, so as to endanger the patient, from the risk of internal inflammation. If we find a large

Account of
W. Hamilton.

large quantity thus evacuated, it will prove the lung of that side to be sound; as, air being entirely excluded, the cavity must be filled up by that alone, after the water is discharged. If little runs off, it is probably one of these cases where the lung is so much indurated as to be for ever incapable of performing its function. In the first case, the patient may derive benefit from the operation; the disease may be prevented from recurring. In the other we have done him no hurt; he will breathe more easily as long as the oozing continues, by taking away the redundant water, but, as this cannot be kept up long, he must at last be left to his fate.

" LAYING the patient on the diseased side after the operation must be of service, as it both allows the water to run off, and it prevents him from enlarging that side of the chest, and thus running a risk of drawing in air by the wound. When a canula is kept in, this is impracticable; the patient cannot be laid much towards that side without the canula pressing on the bed-clothes. In the manner I have proposed, the operation will, I think, be more safely performed, and might therefore be oftener tried.

" WHAT I have said applies only to hydrothorax. In empyema an opening must be kept in the chest, to discharge the matter as it forms. The two diseases certainly require different surgical treatment. In the first, inflammation has not come on, and is to be guarded against. In the other, the collection of matter is the effect of it, and its being regularly discharged will, if any thing can, abate it. I should therefore follow Mr BELL's plan* in this, though I would differ from it in the other; and as the steps of the operation in these two cases would be the same, except leaving in the canula in empyema, we may attempt

* THE canula recommended by Mr BELL has no lip or margin round the opening. By such an addition it has a hold of the parts round the opening, and can be kept much steadier.

it when proper, though we may not be certain of the nature of the fluid contained. In most cases we may ascertain this before from the symptoms; but, at all events, the puncture in the pleura will put it beyond a doubt."

Account of
W. Hamilton.

MR HAMILTON had an opportunity of seeing several herniæ in women, upon some of whom he operated successfully; and, from considering all the cases he had seen, he was led to make the following remarks, some of which he thought new.

"WHEN I began the practice of surgery, as I had never met with a case of hernia in women, I believed implicitly in the doctrines we find in every writer on the subject, viz. that women have seldom bubonocèle, but are more subject to femoral hernia. Soon after I had begun to practise, I was called to a consultation about a woman with a hernia, which had been strangulated for two days. As it was placed in the groin, I at first sight thought it a femoral hernia; but, upon examining it attentively, I found it was a bubonocèle that had gone towards the thigh, in place of towards the labium. The operation which was performed put the matter beyond a doubt, and showed that it came through the ring of the muscle. In a few months I was called to another patient in the same situation, and I found, to my surprise, the same appearances which in the first I took to be a *lusus naturæ*; the hernia in the groin, at the top of the thigh, and yet evidently coming through the ring; having all the appearances at first sight of femoral hernia, but in reality a bubonocèle. The operation here, likewise, which I performed, made me certain of the fact. In a third, under strangulation, I found the same appearances, and operated.

"FINDING the hernia bubonocèle in these three cases, yet with all the appearance of that species where the gut is pushed out under PAUPART'S ligament, I began to suspect that the common account given by authors was erroneous, and that bu-

Account of
W. Hamilton.

bonocele had, from inaccurate observation, been often described for femoral hernia. From the time I began to have these suspicions, I have missed no opportunity of determining my point; and I have been lucky enough to have the dissection of two women, with the apparent femoral hernia, which turned out bubonocoele. I have likewise had five or six living patients with hernia, where I had an opportunity of a careful examination, and have again operated in a similar case. As the result of these ten or twelve cases is against the common opinion, I shall state my observations at full length.

“THE idea that a bubonocoele in women was to take the same road with a similar hernia in men, has, I fancy, misled; for we find, that this is the account commonly given of the disease, that the gut passes down into the labium. Now, if we compare the two cases, we will find there is no similarity. In men, the gut and sack are surrounded by the cremaster, and are therefore conducted towards the testicle. The cellular membrane of the scrotum is free of fat, and therefore yields more easily to the pressure of the gut than that of the parts around; and thus the hernia passes more easily in this direction than in any other. In women, when the hernia has past the ring, it has no cremaster to conduct it to the labium, it may therefore push in any other direction; but as the cellular membrane of the labium, and from it to the ring, is very much loaded with fat in most women, it will find more obstruction in this direction, and will therefore be pushed where the parts yield more readily. The parts on the groin are less loaded with fat, the gut therefore will be pressed here. This I found corroborated by all the three cases, where I either operated or was assistant; and in the two dissections the hernia was pushed outwards from the ring, and in one it had gone up along the belly above the ring. This only takes place when the hernia is small. If the ring is much opened, and a great quantity of gut forced out, the motion of the

the thigh presses it inwards and downwards, and it then goes towards the labium. This I have instances of in some women I have lately examined with herniæ.

"THE appearances of the bubonocoele, when small, will deceive a practitioner if he is not on his guard, and make him imagine it a femoral rupture. The marks by which the one may be distinguished from the other, though situated in the same place, are few and simple.

"AS the fascia of the thigh joins PAUPART'S ligament, the femoral hernia is always under this fascia; it is therefore more compressed; it is not loose, and we cannot so well grasp it with the hand; and, instead of being rounded on the top, it is more or less flattened. The bubonocoele again is only under the skin and cellular membrane, is therefore looser, can be grasped, and is rounded on the top.

"IN femoral hernia the swelling begins at the edge of PAUPART'S ligament, and goes down, and we feel the ring and the parts above the ligament uncovered by the hernia. In the bubonocoele of women it goes over PAUPART'S ligament, and sometimes up upon the muscles over the ring, and extends more to each side along the bending of the thigh than the other.

"FROM these marks not having been attended to, I suspect much that the place where the hernia lay was alone taken into view, and cases similar to mine had been called femoral ruptures. Indeed I have every reason to suppose so, as some of the cases where I was most certain of their being bubonocoele, had been looked on as of the other kind.

"I WOULD therefore recommend to practitioner's attention to these marks, so as to determine how far the observations I have been led to make are just.

"THE bubonocoele in this situation in women, from its often lying in parts over the ring, makes the reduction much more uncertain, as we cannot grasp the part of the hernia just coming
(H 2) through

Account of
W. Hamilton.

through the ring, so as to force it back, which is essentially necessary to ready reduction, and which we can always do in men, from the looseness of the skin at the top of the scrotum.

“UPON examining the state of the parietes of the belly in women, and comparing them with those of men, I see no reason for their being more subject to femoral hernia than bubonocoele, though in general I think them less liable to the disease altogether than men. The figure of the pelvis makes PAUPART'S ligament a little longer in them, but the space under it is in proportion as well filled up by muscles, vessels, and fat, &c. so that no more room is allowed for the viscera to be forced out in the one than in the other. The rings of the muscle in women, though less apt to yield, as being more contracted than in men, are in proportion the weaker part, and therefore the passage through which a viscus will be more readily pushed. In operating upon this species of bubonocoele, I varied a little from the common method. As the tumor extended along the bending of the thigh, my incision being made in this direction, was parallel in some measure to the ring. This made the introduction of the bistoury, to cut the tendon, a little more difficult, but it gave me advantages to counterbalance this inconvenience. I had after the reduction a piece of integuments above the incision, which when pressed down covered the ring. This soon formed adhesion with the parts below, and effectually excluded the exposure of the cavity of the abdomen, which adds much to the danger of the operation. In the common operation, where the ring is laid in view, and is at the bottom of the wound, the integuments over it having been divided, I suspect the inflammation on the edges and bottom of the wound, which is kept open, extends through the ring to the peritonæum, altogether independent of the exposure, and produces very fatal effects. Now, in my method, this was prevented; the integuments being found immediately over the ring. In dressing the wound

wound I used stitches to keep the lips together, which was likewise assisted by bending up the thigh. This I look on as of consequence in every operation for hernia, as the healing the parts by the first intention over the ring must be of essential service in preventing inflammation in the abdomen; and the only objection that has been made to it, the risk of the gut slipping out, may be easily prevented by a compress over the opening in the tendon for a few days: And after this, as adhesions will have taken place, unless great force is used, no protrusion can happen."

Account of
W. Hamilton

To these specimens others might be added, were not this memoir already too long, and were not these sufficient to justify what has been said of the unremitting attention and sound judgment of a gentleman, whose premature death was regarded by all his friends as a loss to science and to society. His constitution, somewhat enfeebled by early and intense application to study, was worn out with the toil of business and thought, in which he was continually engaged; and, after a tedious illness, he expired, March 13. 1790, in the thirty-second year of his age, leaving a widow and two sons.

HAVING lived according to the laws of religion and virtue, and being naturally of a placid, cheerful temper, he bore much suffering without complaint, looking forward to death, which for some time he knew to be unavoidable, with those sensibilities indeed which every good man feels on the prospect of leaving his dearest friends, and entering into an untried existence, but without unmanly dejection or timidity. Besides the approbation of his own mind, he was soothed with the affectionate attentions of all his family, and with the regrets of his brethren and the public, who from day to day testified the utmost solicitude concerning his health; uttering not the unmeaning language of ceremony, or the interested one of flattery, but that of sincere

Account of
W. Hamilton.

sincere esteem and gratitude. Even when his funeral passed along, many among the crowd were observed to shed tears for one whose kindness had soothed their minds, and whose skill had relieved them in the hour of distress; nature prompting them to pay this grateful tribute to him who could no longer observe or reward them.

THE softness and tenderness with which he spoke to his patients; the attention with which he listened to all their complaints, however frivolous; the readiness with which he sympathized with their feelings; to a bystander in health might sometimes appear excessive, but, to the same person in disease, the whole appeared but a reasonable exertion of humanity. Delighted with the kindness of his manner, his patients vied with each other in their commendations, of which he proved himself worthy, by the utmost delicacy of conversation, and the strictest purity of conduct, no less than by exertions of superior skill, and by a punctual laborious attendance. His prudence, which was uncommon for his years, led him to avoid all ostentatious display of the extent to which he was employed; by which means, together with the most modest demeanour, he, in part, stifled that envy which is apt to rise in the old, when they see themselves overtaken or outstripped by the young.

As a lecturer, his manner was remarkably free from pomp and affectation. His language was simple and perspicuous, but so artless, that it appeared flat to those who place the beauty of language in the intricacy of arrangement, or the abundance of figures. His manner of speaking corresponded with his style, and was such as might appear uninteresting to those who think it impossible to be eloquent without violent gestures, and frequent variations of tone. He used nearly the tone of ordinary conversation, as his preceptor Dr HUNTER did before him, aiming at perspicuity only, and trusting for attention to the importance of the subjects he treated. These he selected with great judgment.

judgment. Holding in contempt all hypotheses unsupported by fact, and inapplicable to the improvement of practice; omitting or passing slightly over parts remarkable for curiosity more than utility; he demonstrated with great distinctness and precision those parts which it is necessary to know accurately; accompanying his demonstrations with specimens of morbid parts, and with every remark, physiological or practical, which he was able to collect from extensive reading, and careful reflection on his own practice. To excite emulation among his students, and to honour the memory of his friend, he gave a gold medal, bearing the figure of Dr WILLIAM HUNTER, as a prize to the best dissertation on a surgical subject. By these means, he had the satisfaction of contributing to increase the number of medical students in Glasgow; and while his students became from year to year more numerous, they began to discover also that ardour, which it is impossible either to excite or maintain where the students are few.

Account of
W. Hamilton.

judgment. Holding in contempt all hypotheses unsupported by fact, and inapplicable to the improvement of practice, or passing lightly over parts remarkable for curiousness and novelty, he demonstrated with great distinctness and precision those parts which it is necessary to know accurately, and giving his demonstrations with specimens of natural history, with every remark, physiological or practical, which he was able to collect from extensive reading, and careful collection in his own practice. The exact translation among his students, and the honor the memory of his friend, he gave a good model, and in the figure of Dr William Hunter, as a prize to the best dissertation on a surgical subject. By these means, he had the satisfaction of contributing to increase the number of students in Glasgow, and while his students became from year to year more numerous, they began to discover the great value which it is impossible either to excise or to amputate where the denials are few.

IV. ACCOUNT of JOHN ROEBUCK, M. D. F. R. S. EDIN. Communicated by Mr JARDINE, F. R. S. EDIN. and Professor of Logic in the University of Glasgow.

[Read April 4. 1796.]

DOCTOR JOHN ROEBUCK was born at Sheffield in Yorkshire, in the year 1718. His father was a considerable manufacturer and exporter of Sheffield goods, who, by his abilities and industry, had acquired a competent fortune. JOHN, his eldest son, the subject of this memoir, was intended, by his father, for carrying on his own lucrative business at Sheffield; but was, from his early youth, irresistably attached to other pursuits, more calculated to gratify his ambition, and give fuller play to his powers. Notwithstanding this disappointment in his favourite object, his father had liberality enough to encourage his rising genius, and to give him all the advantages of a regular education.

AFTER he had gone through the usual course of the Grammar-school at Sheffield, both his father and mother being strict dissenters, they placed their son, for some years, under the tuition of the late Dr DODDRIDGE, who was, at that time, master of an Academy at Northampton, and had justly acquired high reputation among the dissenters, both as a divine and as an instructor of youth. Under the Doctor's care Mr ROEBUCK made great proficiency, and laid the foundation of that classical taste and knowledge for which he was afterwards eminently distinguished.

Account of
Dr Roebuck.

guished. It would appear that Dr DODDRIDGE had been much pleased with the ardour and enthusiasm, in the pursuit of knowledge, discovered by his pupil; for, Mr ROEBUCK, in an after period of his life, used frequently to mention the subjects of conversations and inquiries of various kinds, in which the Doctor had engaged him. It was during his residence at this Academy, that he contracted an intimate acquaintance with his fellow-students, Mr JEREMIAH DYSON, afterwards much known in the political world, and Mr MARK AKENSIDE, afterwards Dr AKENSIDE, which terminated only with their lives.

FROM the Academy at Northampton, he was sent to the University of Edinburgh, where he applied to the study of medicine, and particularly to that of chemistry, which, about that time, began to attract some attention in Scotland. While he resided there he distinguished himself much, among his fellow-students, in their literary societies and conversations, by great logical and metaphysical acuteness, and by great ingenuity and resource in argumentation. The late sagacious Dr PORTERFIELD, to whom he had been introduced, observed and encouraged his rising genius, and was greatly instrumental in promoting his improvement. There, too, he formed an intimate acquaintance with Mr HUME, Mr ROBERTSON, afterwards Dr ROBERTSON, Mr PRINGLE, afterwards Lord ALEMOOR, and several other persons of literary eminence; a circumstance which produced, in his mind, a partiality ever afterwards in favour of Scotland, and contributed not a little to his making choice of it for the chief field of his future exertions and industry.

AFTER Mr ROEBUCK had gone through a regular course of medical education at Edinburgh, being now determined to follow the practice of physic, he next spent some time at the University of Leyden, then in high reputation as the first school of medicine in Europe: There, after the usual residence and course of trials, he obtained a degree in medicine; and his diploma, dated

dated 21st February 1743, has affixed to it the respectable names of MUSCHENBROEK, OSTERDYK, VAN ROYEN, ALBINUS, GAUBIUS, &c. He left Leyden, after having visited some part of the north of Germany, about the end of the year 1744.

SOON after his return from the Continent, some circumstances induced Dr ROEBUCK to settle, as a physician, at Birmingham. Before that time, Birmingham had begun to make a rapid progress in arts, manufactures, and population, and, by the death of an aged physician, an opening was presented to him, which afforded an immediate prospect of encouragement in that line. His education, talents, and interesting manners, were well calculated to promote his success as a physician. He accordingly met there, at a period more early than he expected, with great encouragement, and was soon distinguished, in that town, and the country adjacent, for his skill, integrity, and charitable compassion, in the discharge of the duties of his profession.

It appeared, however, soon after his residence was fixed at Birmingham, that his studies and industry were turned to other objects besides those of his profession. Strongly attached to the rising science of chemistry, he conceived high views of extending its usefulness, and of rendering it subservient to the improvement of arts and manufactures. With this view, he fitted up a small laboratory in his own house, in which he spent every moment of his time, which he could spare from the duties of his profession. There, in the true spirit of his great master, Lord BACON, of whose philosophy he was a great admirer, he carried on various chemical processes of great importance, and laid the foundation of his future projects, on well tried and well digested experiments*.

(I 2)

THE

* *Verus experientiae ordo, primo lumen accendit, deinde per lumen iter demonstrat, incipiendo ab experientia ordinata et digesta, atque ex ea, et educendo axiomata, et axiomatibus constitutis, rursus experimenta nova.*

Account of
Dr Roebuck.

THE first efforts of his genius and industry, thus directed, led him to the discovery of certain improved methods of refining gold and silver, and particularly to an ingenious method of collecting the smaller particles of these precious metals, which had been formerly lost in the practical operations of many of the manufacturers. By other chemical processes, carried on about the same time in his little laboratory, he discovered also improved methods of making sublimate, hartshorn, and sundry other articles of equal importance. After having received full satisfaction from the experiments upon which such discoveries and improvements were founded, he next digested a plan for rendering them beneficial to himself, and useful to the public. A great part of his time being still employed in the duties of his profession, he found it necessary to connect himself with some person in whom he could repose confidence, and who might be, in other respects, qualified to give him support and assistance in carrying on his intended establishments. With this view, he chose as his associate Mr SAMUEL GARBET of Birmingham, a gentleman well qualified by his abilities, activity, and enterprising spirit, for bearing his part in their future undertakings. Their first project was the establishment of an extensive laboratory at Birmingham, for the purposes above mentioned, which, conducted by Dr ROEBUCK's chemical knowledge, and Mr GARBET's able and judicious management, was productive of many advantages to the manufacturers of that place, and of such emolument to themselves, as contributed greatly to the boldness of their future projects. That laboratory has, ever since that time, continued at Birmingham, and is still conducted by Mr GARBET. Dr ROEBUCK, long before his death, had given up his interest in it.

ABOUT this time, in 1747, the Doctor married Miss ANN ROE of Sheffield, a lady of a great and generous spirit, whose temper and disposition equally fitted her for enjoying the prosperous

sporous circumstances of their early life, and for bearing her equal share of those anxieties and disappointments in business which shaded, but did not obscure, the later period of their lives.

Account of
Dr Roebuck.

DR ROEBUCK'S unremitted perseverance in his chemical studies, together with the success that attended them, led him, step by step, to other researches of great public and private benefit.

THE extensive use of the vitriolic acid in chemistry, and the prospect of its application to some of the mechanic arts, had produced a great demand for that article, and turned the attention of chemists to various methods of obtaining it. The late Dr WARD had obtained a patent for making it; and, though the substances from which it might be obtained, as well as certain methods of obtaining it, had been known to others, and particularly pointed out by LEMERY the elder, and by GLAUBER, yet Dr WARD was the first, it is believed, who established a profitable manufacture upon the discovery. Much, however, was wanting to render the acid of universal use in chemistry, and of extensive utility in the arts, where great quantities of it were required. The price of it was high, arising from the great expence of the glass vessels, which were made use of by Dr WARD in procuring it, and the frequent accidents to which they were liable in the process.

DR ROEBUCK had been, for some time, engaged in making experiments with a view to reduce the price, and at length discovered a method of preparing it, by substituting, in place of the glass vessels formerly used, lead ones of a great size; which substitution, together with sundry other improvements in different parts of the process, completely effected his end.

AFTER the necessary preparations had been made, Messrs ROEBUCK and GARBET established a manufacture of the oil of vitriol at Prestonpans, in Scotland, in the year 1749. This establishment not a little alarmed Dr WARD, who attempted to defeat

Account of
Dr Roebuck.

feat their plan, by taking out a patent for Scotland, in addition to the one he had formerly obtained. In this attempt he failed. Dr ROEBUCK's discovery was found not to come within the specification of Dr WARD's patent.

THE Prestonpans Company, convinced that patents are of little avail in preserving the property of new inventions or discoveries, in conducting their vitriol works resolved to have recourse to the more effectual methods of concealment and secrecy. By that method they were enabled to preserve the advantages of their ingenuity and industry for a long period of years, and not only served the public at a much cheaper rate than had ever been done formerly, but, it is believed, they realized, in that manufacture, a greater annual profit from a smaller capital than had been done in any similar undertaking. The vitriol work is still carried on at Prestonpans; but, long before Dr ROEBUCK's death, he was obliged to withdraw his capital from it.

ABOUT this time Dr ROEBUCK was urged, by some of his friends, to leave Birmingham, and to settle as a physician in London, where his abilities might have had a more extensive field of exertion. He had been early honoured with the acquaintance of the late Marquis of ROCKINGHAM, who, as a lover of arts, had frequently engaged him in chemical experiments at Rockingham-house. It was there, also, he became acquainted with the late Sir GEORGE SAVILLE, and with several other persons of rank and influence. His old friend and school-fellow, Mr DYSON, too, by this time, had acquired considerable name and influence, and pressed him much to take that step. Under such patronage, and with the energy of such talents as Dr ROEBUCK possessed, there could be little doubt of his soon arriving at an eminent rank, as a physician in London. But the chemical concerns, with which he was at that time deeply occupied, held out to him a prospect of a richer harvest, determined him to give up the practice of medicine altogether, and

and to fix his residence, for the greatest part of the year, in Scotland.

Account of
Dr Roebuck.

THE success of the establishment at Prestonpans, which had far exceeded their expectation, enabled the Doctor and his partner Mr GARBET, to plan and execute other works of still greater benefit and public utility. In the prosecution of his chemical studies and experiments, Dr ROEBUCK had been led to bestow great attention on the processes of smelting ironstone, and had made some discoveries, by which that operation might be greatly facilitated, particularly by using pitcoal in place of charcoal. Mr WILLIAM CADDELL of Cockenzie, in the neighbourhood of Prestonpans, a gentleman earnestly intent upon promoting manufactures in Scotland, had, for several years, laboured, without much success, in establishing a manufacture of iron; a circumstance which may have probably contributed to turn Dr ROEBUCK's attention more particularly to that subject. As the capital which he and his partner Mr GARBET could appropriate for carrying on the iron manufacture was not equal to such an undertaking, and chiefly depended upon the profits of their other works, their first intention was to attempt a small establishment of that kind, in the vicinity of their vitriol works at Prestonpans. But the flattering prospects of success, arising from a course of experiments which Dr ROEBUCK had lately made, encouraged them to extend their plan, and to project a very extensive manufactory of iron. A sufficient capital was soon procured, through the confidence which many of their friends reposed in their abilities and integrity. In fact, the establishment which they made, or rather the capital which gave it existence, was the united capital of a band of relations and friends, who trusted to Dr ROEBUCK and Mr GARBET the management of a great part of their fortune. When all previous matters had been concerted, respecting their intended establishment, the chief exertions of chemical and mechanical

Account of
Dr Roebuck.

chanical skill, necessary in the execution, were expected from Dr ROEBUCK. It fell to his share also to fix upon the best and most favourite situation for erecting their intended works. With that view, Dr ROEBUCK examined many different places in Scotland, particularly those on both sides of the Frith of Forth; and, after a careful and minute comparison of their advantages and disadvantages, he at length made choice of a spot, on the banks of the river *Carron*, as the most advantageous situation for the establishment of the iron manufacture. There, he found, they could easily command abundance of water for the necessary machinery; and in the neighbourhood of it, as well as every where both along the north and south coasts of the Frith, were to be found inexhaustible quarries of ironstone, limestone, and coal. From Carron, also, they could easily transport their manufactures to different countries by sea. The communication with Glasgow, at that time, by land-carriage, which opened up to them a ready way to the American market, was short and easy.

MANY other things, which need not be here enumerated, fell to Dr ROEBUCK's share in preparing and providing for the introduction of this new manufacture into Scotland, particularly with respect to the planning and erection of the furnaces and machinery. To insure success, in that department, nothing was omitted which ability, industry, and experience could suggest. With this view, he called to his assistance Mr SMEATON, then by far the first engineer in England. It was from him he received plans and drawings of the water-wheels and blowing apparatus, which, notwithstanding all the mechanical improvements which have been made since, remain unrivalled in any of the other ironworks erected in Britain. This was the first introduction of Mr SMEATON into Scotland, and was the occasion of various other displays of the skill and experience of that celebrated engineer in that part of the island.

With

With the same view, and to the same effect, in a future period of his operations, he employed Mr JAMES WATT, then of Glasgow, and had the merit of rendering that inventive genius, in the mechanical arts, better known both in this country and in England.

Account of
Dr Roebuck.

THE necessary preparations, for the establishment of the iron-works at Carron, were finished in the end of the year 1759; and on the 1st January 1760 the first furnace was blown: and in a short time afterwards a second was erected.

No period of Dr ROEBUCK's life required from him more vigorous and laborious exertions than that of the establishment of the Carron works, and the first trials of the furnaces and machinery. His family and friends remember well the ardour and interest which he discovered; the incessant labour and watchfulness which he exerted on that occasion. Every thing was untried, the furnaces, the machinery, the materials, the workmen; the novelty of the undertaking in that country, its extent and difficulty, and the great stake at issue, were circumstances that must have occasioned much serious thought and anxiety to the partner, upon the credit of whose knowledge and experience the work had been undertaken. But the Doctor had great powers and great resources: and the first trial gave sufficient indications of future success.

FOR some time after the establishment of the Carron works, Dr ROEBUCK continued to give his attention and assistance in the general management and superintendence of them, and with him all measures of future operations were concerted. During this period, some alterations of great importance were suggested by him, and carried into effect. By carefully observing the progress of smelting in the furnaces, at first worked by bellows, besides their being subject to various accidents, the Doctor discovered the necessity of rendering the blast both stronger and more equable; and proposing, as a problem to Mr

Account of
Dr Roebuck.

SMEATON, the best method of effecting that end, that celebrated engineer soon gave the plan of a blast by three or four cylinders, which was afterwards tried, and succeeded even beyond expectation.

WHEN the business at Carron sunk by degrees into a matter of ordinary detail, and afforded less scope for the Doctor's peculiar talents, he was unfortunately tempted to engage in a new and different undertaking; from the failure of which he suffered a reverse of fortune, was deprived of the advantages resulting from his other works, and, during the remainder of his life, became subjected to much anxiety and disappointment.

THE establishment of the Carron works, and the interest Dr ROEBUCK had in their success, had naturally turned his attention to the state of coal in the neighbourhood of that place, and to the means of procuring the extraordinary supplies of it which the ironworks might in future require. With the view, therefore, of increasing the quantity of coal worked in that neighbourhood, by an adventure which he thought would also turn out to his own emolument, he was induced to become lessee of the Duke of HAMILTON's extensive coal and salt works at Borrowstounness. The coal there was represented to exist in great abundance, and understood to be of superior quality; and as Dr ROEBUCK had made himself acquainted with the most improved methods of working coal in England, and then not practised in Scotland, he had little doubt of this adventure turning out beneficial and highly lucrative. In this, however, he was cruelly disappointed. The opening of the principal *stratum* of coal required much longer time, and much greater expence, than had been calculated; and, after it was opened, the perpetual succession of difficulties and obstacles which occurred in the working and raising of the coal, was such as has been seldom experienced in any work of that kind. The result was, that after many years

of

of labour and industry, there were sunk in the coal and salt works at Borrowstounness, not only his own, and the considerable fortune brought him by his wife, but the regular profits of his more successful works; and, along therewith, what distressed him above every thing, great sums of money borrowed from his relations and friends, which he was never able to repay: not to mention, that, from the same cause, he was, during the last twenty years of his life, subjected to a constant succession of hopes and disappointments, to a course of labour and drudgery ill suited to his taste and turn of mind, to the irksome and teasing business of managing and studying the humours of working colliers. But all these difficulties his unconquerable and persevering spirit would have overcome, if the never ceasing demands of his coal-works, after having exhausted the profits, had not also compelled him to withdraw his capital from all his different works in succession; from the refining work at Birmingham, the vitriol work at Prestonpans, the ironworks at Carron, as well as to part with his interest in the project of improving the steam-engine, in which he had become a partner with Mr WATT, the original inventor, and from which he had reason to hope for future emolument. It would be painful to mention the unhappy consequences of this ruinous adventure to his family and to himself. It cut off for ever the flattering prospect which they had of an independent fortune, suited to their education and rank in life. It made many cruel encroachments upon the time and occupations of a man, whose mind was equally fitted to enjoy the high attainments of science, and the elegant amusements of taste. As the price of so many sacrifices, he was only enabled to draw from his colliery, and that by the indulgence of his creditors, a moderate annual maintenance for himself and family during his life. At his death, his widow was left without any provision whatever for her immediate or future support,

(K 2) and

Account of
Dr Roebuck.

Account of
Dr Roebuck.

and without the smallest advantage from the extraordinary exertions and meritorious industry of her husband.

DR ROEBUCK had, some years before his death, been attacked by a complaint that required a dangerous chirurgical operation. That operation he supported with his usual spirit and resolution. In a short time he was restored to a considerable share of his former health and activity. But the effects of it never entirely left him, and several slighter returns of the complaint gradually impaired his constitution. He still, however, continued, till within a few weeks of his death, to visit his works, and to give direction to his clerks and overseers. He was confined to his bed only a few days, and died on the 17th July 1794, retaining to the last all his faculties, his spirit and good humour, as well as the great interest which he took, as a man of science and reflexion, in the uncommon events which the present age has exhibited.

FROM a man so deeply and so constantly engaged in the detail of active business, many literary compositions were not to be expected. DR ROEBUCK left behind him many *works*, but few *writings*. The great object which he kept invariably in view was to promote arts and manufactures, rather than to establish theories or hypotheses. The few essays which he left, enable us to judge of what might have been expected from his talents, knowledge, and boldness of invention, had not the active undertakings in which, from an early period of life, he was engaged, and the fatiguing details of business, occupied the time for study and investigation. A comparison of the heat of London and Edinburgh, read in the Royal Society of London June 29. 1775, Experiments on ignited bodies, read there 16th February 1776, Observations on the ripening and filling of corn, read in the Royal Society of Edinburgh 5th June 1784, are all the writings of his, two political pamphlets excepted, which have been published. The publication of the essay on ignited bodies was
occasioned

occasioned by a report of some experiments made by the Comte DE BUFFON, from which the Comte had inferred, that *matter* is heavier when hot than when cold. DR ROEBUCK's experiments, made with great accuracy before a committee of the Royal Society at London, seem to refute that notion.

Account of
Dr Roebuck.

It is the works and establishments projected and executed by DR ROEBUCK, with the immediate and more remote effects of them upon the industry, arts, and manufactures of Scotland, which urge a just claim to the respect and gratitude of his country. This tribute is more due from the discerning part of mankind, as this species of merit is apt to be overlooked by the busy or the superficial, and to fail in obtaining its due reward. The circumstances of DR ROEBUCK have, in this respect, been peculiarly hard. For though, most certainly, the projector and author of new establishments highly useful to his country, and every day becoming more so, he was, by a train of unfortunate events, obliged to break off his connexion with them, at an unreasonable time, when much was yet wanting to their complete success: and thus he left others in the possession, not only of the lucrative advantages now derived from them, but even, in some measure, of the general merit of the undertaking, to a considerable part of which he had the most undoubted claim.

THE establishment of the laboratory at Birmingham, in the year 1747, the first public exhibition of his chemical talents, was, at that particular period, and in the state of the arts and manufactures at that time, highly beneficial, and subservient to their future progress: and the continuance and success of it, in that place, is a proof of the advantages which many of the manufacturers receive from it. Much had already been done, and many improvements made in arts and manufactures, chiefly by the suggestions of that ingeniousness and experience, which, in the detail of business, might be expected from the practical artist. DR ROEBUCK was qualified to proceed a step farther; to direct

Account of
Dr Roebuck.

direct experience by principles, and to regulate the mechanical operation of the artist by the lights of science. The effects of that establishment extended, in a particular manner, to all that variety of manufactures in which gold and silver were required, to the preparing of materials, the simplifying of the first steps, to the saving of expence and labour, and to the turning to some account what had been formerly lost to the manufacturer. It is well known, that, while Dr ROEBUCK resided at Birmingham, such was the opinion formed of his chemical knowledge and experience by the principal manufacturers, that they usually consulted him on any new trial or effort to improve their several manufactures; and, when he left that place, they sincerely regretted the loss of that easy and unreserved communication they had with him, on the subjects of their several departments.

ON account of similar circumstances, the benefit to the public, from the establishment of the vitriol works at Prestonpans, in the extension and improvement of many of the arts, cannot now be exactly ascertained. The vitriolic acid is one of the most active agents in chemistry, and every discovery which renders it cheap, and accessible to the chemist, must be greatly subservient to the progress of that science. By the establishment at Prestonpans, the price of that valuable acid was reduced from sixteen to four pence *per* pound. It is to Dr ROEBUCK, therefore, that chemists are indebted for being in possession of a cheap acid, to which they can have recourse in so many processes.

BUT Dr ROEBUCK's object, in the prosecution of that scheme, was not so much to facilitate the chemist's labour, as to render that acid, in a much higher degree than it had formerly been, subservient to many of the practical arts. By rendering the vitriolic acid cheap, great use came to be made of it in preparing the muriatic acid, and GLAUBER's salts from common salts. Its use has been farther extended to many metallic processes; and it has lately been employed in separating silver from the

the clippings of plated copper, the use of which is very extensive.

Account of
Dr Roebuck.

THE application of the vitriolic acid in bleaching linen, or a substitution of it for sour milk, was first published by Dr FRANCIS HOME. But it is well known to several of Dr ROEBUCK's chemical friends, that he had tried it, found it effectual, and had frequently recommended it to bleachers before the date of that publication. The quantity of it now consumed in that art is very great. Of late it has been used in decomposing common salt, with the addition of manganese, in order to obtain the oxygenated muriatic acid, by which the process of bleaching fine linen is amazingly shortened. Much of it too is used in preparing the best kind of aquafortis, or nitrous acid, from saltpetre, which was decomposed formerly, and still is, in many cases, by vitriol, instead of the vitriolic acid; but the vitriol gives an aquafortis of inferior strength and purity. The dyers also employ great quantities of it in different processes, particularly in dissolving indigo, in one of their methods of dying with that drug.

AT first, the manufactories of the vitriolic acid in Britain supplied foreign nations as well as our own, though foreigners, having since discovered or learned the art, now make it themselves. But it would be tedious to mention all the applications of it which have been already made, and it is impossible to say how far the use of this powerful agent in chemistry, and the arts, may be carried. Enough has been said to show, that Dr ROEBUCK's discoveries, in that department, have been of the greatest advantage to science and the practical arts, in facilitating the process for procuring this acid, and in rendering it of general use; and it is but fair that the name of that person should stand on record, to whom chemists and artists are so much indebted for their subsequent successful labours.

THE

Account of
Dr Roebuck.

THE project and establishment, however, of the ironworks at Carron, the most extensive establishment of that kind hitherto in Britain, must be considered as Dr ROEBUCK's principal work. The great and increasing demand for iron in the progressive state of arts, manufactures and commerce in Britain, and the great sums of money sent every year to the north of Europe for that article, turned the attention of chemists and artists to the means of promoting the manufacture of iron, with the view of reducing the importation of it. No person has a better founded claim to merit, in this particular, than Dr ROEBUCK. The smelting of iron by pitcoal, it is indeed believed, had been attempted in Britain in the beginning of the last century. In the reign of JAMES I. several patents seem to have been granted for making hammered iron by pitcoal, particularly to the Honourable DUD DUDLEY and SIMON STARLEVANT. It does not appear, however, that any progress had been made in the manufacture in consequence of these patents. In later times trials have been made by so many different persons, and in so many different places in England, nearly about the same time, that it may be difficult to say where and by whom the first attempt was made, particularly as the discoverers of such processes wished to conceal the knowledge they had gained as long as they could. But Dr ROEBUCK was certainly among the first, who, by means of pitcoal, attempted to refine crude or pig iron, and to make bar iron of it, instead of doing it by charcoal, according to the former practice: And he was, without all question, the person who introduced that method into Scotland, and first established an extensive manufacture of it. It is not meant to ascribe to him the sole merit of the establishment at Carron. No man was ever more ready than he was, to do justice to the abilities and spirit of his friends and partners, Messrs GARBET, CADDELL, &c. who first embarked with him in that great undertaking. But still it may be said with truth, that
the

Account of
Dr Roebuck.

the original project of the ironworks at Carron, the chemical knowledge and experience on which they were founded, the complicated calculations which were previously required, the choice of the situation, the general conduct and direction of the buildings and machinery, the suggestion of many occasional improvements, together with the removal of many unforeseen obstacles and difficulties, which occurred in the infant state of that establishment, were, in a great measure, the work and labour of Dr ROEBUCK. Nor can it, with the least shadow of justice, detract from his merit, that a larger capital, and greater expence than was at first calculated, have been found necessary to bring the works at Carron to their present state of perfection; or, that great alterations and improvements have taken place, during the course of forty years, in a great and progressive establishment. In all works of that kind, the expence exceeds the calculation. The undertakers even of the latest ironworks which have been erected, notwithstanding all the advantages obtained from recent experience, will be ready to acknowledge, that, in these respects, there is little room to blame the original projector of the first establishment of that kind in Scotland. But the best, and most infallible proof of Dr ROEBUCK's merit, and of the sound principles on which these works were established, is the present prosperous state of that establishment, the great perfection of many branches of their manufactures; and, particularly, the many extensive and flourishing ironworks, which have been since erected upon the model of Carron, in different parts of Scotland, at Cleugh, Clyde, Muirkirk, and Devon. It cannot be denied that all these works have sprung from the establishment at Carron, and are ultimately founded upon the knowledge and experience which have been obtained from them; for some of the partners, or overseers of these new works, and many of the workmen, have been, at one time or another, connected with that of Carron. Hence, then, it is ow-

Account of
Dr Roebuck.

ing to the projector and promoter of the establishment at Carron, that Scotland is, at this moment, benefited to the amount of many hundred thousand pounds, in working up the raw materials of that manufacture found in the country itself, and which, previous to that establishment, was of no value whatever. Such are the *present*, but scarcely any idea can be formed of the *future* advantages to this country, which may be derived from the extension of the iron manufacture. About 60,000 tons of iron have been annually imported into Great Britain for more than twenty years past, and though there has been, for some time, about 20,000 tons of bar iron made in Britain by pitcoal, yet the foreign imported iron has suffered little or no diminution in quantity. This great consumption of iron, no doubt, is owing to the various improvements of late years, and the general extension throughout all Europe of commerce and the arts. The manufacture of iron must therefore continue to increase, and Scotland, abounding every where in ironstone, pitcoal, and in command of water for machinery, has the prospect of obtaining the largest share of it.

To the establishment of the Carron works, and to the consequences of that establishment, may be ascribed also the existence of other public works in Scotland of great importance and utility. The opening of a communication by water betwixt the Forth and the Clyde had long been projected, and frequently the subject of conversation in Scotland, but nothing in fact had been attempted. The establishment of the ironworks at Carron soon called forth sufficient interest and enterprise to bring about the execution of this grand design. Some of the partners of the Carron Company, foreseeing the advantages they would derive from such a communication, proposed, at their own expence, to execute a small canal; and, after taking the preparatory steps, actually applied to Parliament to obtain authority for that purpose. But the project of the small canal

not meeting with the approbation of some noblemen and gentlemen in that part of Scotland, they opposed the bill, and obliged themselves to execute a greater canal, which has now been many years finished, and is found to be of the greatest advantage to the trade and commerce of Scotland. The merit of this undertaking is not meant to be ascribed to Dr ROEBUCK, excepting in so far as it necessarily arose from the establishment of the Carron Company, of which he was the original projector; and it may reasonably be doubted, whether, without that establishment, it would have yet taken place. Several other canals have, since that time, been executed in different parts of Scotland, and other very important ones are at present projected.

Account of
Dr Roebuck.

The different establishments which Dr ROEBUCK made at Borrowstounness in carrying on the coal and salt works there, though ultimately of no advantage to himself, were attended, during the course of thirty years, with the most beneficial effects upon the trade, population, and industry of that part of Scotland. They were the means also of adding very considerably to the public revenue. Previous to the time these works fell under Dr ROEBUCK's management, they produced no advantage either to the proprietor, or the adventurers, or to the public. But by his mode of conducting them upon a more extensive plan, by opening up new seams of coal, and of better quality, he was enabled to export a very considerable quantity, to increase the quantity of salt, and, of course, the revenue arising from these articles. In these works, and in the management of a large farm, Dr ROEBUCK gave employment to near a thousand persons at Borrowstounness, and in the neighbourhood.

NOR was it solely by the different establishments which he projected and executed, but by many other things necessarily connected with them, that Dr ROEBUCK's labours were beneficial to Scotland. Along with them he may be said to have introduced

Account of
Dr Roebuck.

ced a spirit of enterprise and industry, before that time little known in Scotland, which soon pervaded many other departments of labour, and gave birth to many other useful projects. He brought from England, then much farther advanced in arts and industry, many ingenious and industrious workmen, at great expence, who, by their instructions and example, communicated and diffused skill and knowledge to others. At all times Dr ROEBUCK held out liberal encouragement to rising genius, and industrious merit; and spared no expence in making trials of improvements and discoveries, which were connected with the different projects and works which he was carrying on.

SUCH was the active and useful life of Dr ROEBUCK, a man of no common cast, who united, in a very high degree, a great number of solid and brilliant talents, which, even separately, fall to the lot of but few individuals. Distinguished by an ardent and inventive mind, delighting in pursuit and investigation, always aspiring at something beyond the present state of science and art, and eagerly pressing forward to something better or more perfect, he thus united energies the most powerful, with the most unwearied and persevering industry. To that peculiarity of imagination, so fitted for scientific pursuit, which readily combines and unites, which steadily preserves its combinations before the eye of the mind, and quickly discovers relations, results and consequences, was added, in his character, great promptitude and firmness in decision. Strongly and early impressed with the great importance of applying chemical and physical knowledge to the useful arts, to the melioration of civil life, he never lost sight of that favourite view, and discovered great boldness and resource in the means and expedients which he adopted to promote it. He was certainly master of the best philosophy of chemistry known in the earlier parts of his life, and though, in every stage of that science, he marked and understood the progress of the discoveries, yet his
numerous

numerous avocations did not permit him to follow them out by experimental processes of his own. Upon that, and indeed almost upon every subject, his mind readily grasped the most useful and substantial points, and enabled him to throw out such hints, and hypotheses, as marked him the man of genius.

DURING the course of a regular education, both at Edinburgh and at Leyden, Dr ROEBUCK studied the classic authors with great attention, particularly the historical and political parts of their works. Upon these subjects he had read much, selected with judgment, and was well acquainted with the facts and philosophy of ancient governments. This taste he carried with him, and improved in every period of his life, and in every situation. It abundantly rewarded him for the earnestness and diligence with which it had been acquired. It became his favourite resource, and indeed one of the chief enjoyments of his life. Possessing the happy talent of turning his mind from serious and fatiguing, to elegant and recreating pursuits, it was no uncommon thing with him to return from the laboratory or the coalpit, and draw relaxation or relief from some one or other of the various stores of classical learning.

No man was better acquainted with the history of his country than Dr ROEBUCK, or more admired and revered the constitution of its Government. By temper and education he was a Whig, and at all times entered, with great warmth, into the political disputes and controversies which agitated parties, in the different periods of his life. If the natural warmth of his temper, and his enthusiasm on these subjects, led him, on some occasions, beyond the bounds of candid argumentation, his quick sense of decorum, and his perfect habits of good manners, produced an immediate atonement, and restored the rights of elegant and polished conversation.

THE general acquaintance which Dr ROEBUCK had acquired with natural and experimental philosophy, together with his
classical

Account of
Dr Roebuck.

classical and political knowledge, rendered him an agreeable companion to the learned, almost of every department, and procured him the attachment and friendship of many of the first literary characters in Britain. With his friend Dr BLACK he lived, till his death, in close habits of intimacy ; and he often acknowledged, with much frankness, the advantages which he derived, in his various pursuits, from a free and unreserved communication with that eminent chemist.

THE amiable dispositions of sensibility, humanity, and generosity, which strongly marked his character, in the general intercourse of society, were peculiarly preserved and exercised in the bosom of his family, and in the circle of his friends. In the various relations of husband, father, friend, or master, and in the discharge of the respective duties arising from them, it would not be easy to do justice to his character, or to determine in which of them he most excelled ; nor must it be forgot, for it reflected much honour on his benovolent heart, that his workmen not only found him at all times a kind and indulgent master, but many of them, when their circumstances required it, a skilful and compassionate physician, who cheerfully visited the humblest recesses of poverty, and who attached them to his service by multiplied acts of generosity and kindness.

WE cannot conclude this narrative, without expressing our regret, that talents so great, and services so useful to his country, as were those of Dr ROEBUCK, should have turned out of so little account to himself and his family. But this is, in fact, no uncommon case. The great benefactors of society have never been men actuated by gain or interest, but those whose ambition was fixed on promoting the convenience and happiness of men. The Doctor had in fact too little regard for money, and was generous in the extreme. It must be confessed, too, that his confidence and ardour prevented him from foreseeing some of the difficulties and obstacles he met with, and frequently tempted him

him to lay out large sums, in the prosecution of some of his projects, without sufficient œconomy, and, of course, without proper returns. His open, unsuspicious temper, also, led him frequently to put too much trust and confidence in some of those who had the charge of his works, which proved to him the cause of many cruel disappointments. But even from his errors and failure the public have derived advantage; and it is surely indisputable, that a man, who passed sixty years in acquiring knowledge, and enlightening his countrymen, is well entitled to the gratitude of his country. During his life, his public services were not altogether overlooked. He often met with flattering marks of approbation from many liberal and public spirited noblemen and gentlemen in this country; and the City of Edinburgh, then under the auspices of Provost DRUMMOND, when they honoured him with the freedom of their City, was pleased to add in his diploma, "That it was given for eminent services done to his country." But enough has not yet been done. Some farther tribute is due to his memory: For there is a just debt of gratitude constituted against the public, which cannot be considered as discharged, as long as the Widow of Dr ROEBUCK, whose fortune was sunk in these great undertakings, is left without any provision for her immediate or future support.

END OF THE HISTORY.

*The Biographical Account of Dr ROBERTSON, read before
the Society March 21. and May 9. 1796, will appear in
the next Volume of the Transactions.*

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. IV. PART II.

PAPERS READ BEFORE THE SOCIETY.

I.

PAPERS OF THE PHYSICAL CLASS.

- I. ACCOUNT of a MINERAL from STRONTIAN, and of a peculiar Species of EARTH which it contains. By THOMAS CHARLES HOPE, M. D. F. R. S. EDIN. Professor of Medicine in the University of Glasgow, and Physician to the Glasgow Royal Infirmary.

[Read Nov. 4. 1793.]

THE mineral, of which I have the honour to lay an account before the Society, was brought to Edinburgh in considerable quantity about six years ago by a dealer in fossils, though indeed it had found its way, long before this period, into one or two collections.

By some it was mistaken for fluor. Its great specific gravity, its fibrous appearance, and its quality of forming an insoluble substance with sulphuric acid, made it generally be received as the native carbonate of barytes. From a few experiments, I was led at that time to entertain some doubt of its being any form of barytes; and for several years, when I filled the chemical chair in the University of Glasgow, I used, when I exhibited the mineral itself, to mention in my lectures such of its properties as I had discovered, and which indicated that it did not belong to the barytic genus. Towards the end of the year

1791, I commenced and executed a series of experiments, the detail of which I laid before the College Literary Society of this place in March 1792. These not only satisfied me that I had been right in my conjecture, which was, that this mineral differs from aerated barytes, but also gave reason to imagine, that it contains a peculiar and hitherto unknown kind of earth. Other experiments, more lately performed, strongly confirm, and perhaps I may add, establish this notion.

Dr CRAWFORD, having remarked the conspicuous difference in the form of the crystals of the muriate of this fossil and of the muriate of barytes, and in their solubilities in water, has thrown out a conjecture to the same purpose, at the end of his paper on the Muriated Barytes, in the second volume of the London Medical Communications.

2. THE mineral of which I have been speaking, I am informed, is found in the lead mine of Strontian in Argyleshire. It lies imbedded in the metalliferous vein, scattered among the ore and the different species of spar that are most commonly met with in such situations. I have specimens in which portions of lead-ore are attached to this mineral, and others in which it, calcareous and ponderous spars, are intermingled in large and considerable masses.

More obvious Qualities.

3. THE appearance of this fossil varies in different samples. It universally possesses the sparry structure, and sometimes bears a strong resemblance to some sorts of calcareous or fluor spars. Its texture is commonly fibrous. The fibres sometimes are slender, and in close contact with each other, so as to give the mass a considerable degree of compactness. At other times the fibres are much more gross, and assume a kind of columnar appearance. The fibres or columns have, in the greater number of specimens, a degree of divergency, issuing as radii from

a centre. The uniformity of this radiation is frequently interrupted by the fibres proceeding from different points of convergence, crossing and intersecting each other. Occasionally on the surface, but more frequently in vacuities within the mass, the mineral is discovered shooting into slender prismatic or columnar crystals of various lengths. Some of these end obtusely, others of them in a sharp point; they are generally striated, and have six sides. I have seen these crystals traversing the cavities in the form of the finest and most delicate spiculæ, and when disposed in a radiated form, equalling in delicacy, and resembling in appearance, the most exquisite zeolites. In other portions, the striated fibrous contexture is scarcely discernible. Sometimes the Strontian spar is transparent and colourless, more commonly it has a tinge of yellow or green, and some diversity is observable in the depth of the tint.

4. It is not so hard as to scintillate; it may be scratched by a knife; it readily yields to the stroke of the hammer; it has no particular fracture, though it commonly breaks along the direction of the fibres.

5. It is a heavy species of spar, having a specific gravity, going between 3.650 and 3.726.

Chemical Qualities.

6. THIS mineral to the taste is insipid, and is only in a small degree soluble in water. I boiled ten grains of it, reduced to a very fine powder, in four ounces of distilled water for some time; about two grains and a half were dissolved.

7. It is powerfully attacked by several of the acids, and a solution takes place in some of them. This is accompanied by a lively and brisk effervescence, which in this as in every other instance, proceeds from the disengagement of an aerial fluid.

8. THE gas that arises during a solution of this mineral in muriatic acid, extinguishes the flame of a candle, and is absorbed

forbed by water. The water thereby acquires the taste of water impregnated with fixed air or carbonic acid, and the property of precipitating lime-water and of redissolving the precipitate when added to excess; from which circumstances I infer, that the elastic fluid that is disengaged is carbonic acid gas.

9. To discover how much of this acid it contains, I dissolved in diluted muriatic acid 960 grains, using every precaution to prevent any thing but elastic fluid from escaping during the effervescence. The diminution of weight that took place amounted to 290 grains. This corresponds with the result of several other experiments made with the same intention. This spar consequently contains 30.2 *per cent.* of carbonic acid.

10. HAVING premised thus much with regard to the action of acids in general on the fossil, and concerning its composition, I shall delay mentioning its habitudes with each till I have detailed the effects of heat upon it.

11. WHEN heat is applied to the Strontian spar, it crackles a little, and as the temperature increases it loses its transparency, becomes white, opaque, and in some measure friable. It requires, however, a very strong fire to produce any further change.

12. I PUT two pieces, weighing together 320 grains, into a small crucible, and inverting another over it, I placed it in an open fire. In this situation it remained for three hours, the fire being good, and at different times animated by means of bellows. These pieces retained their form; they were white, opaque and brittle, and had lost only two grains of their weight. Their chemical properties were unaltered.

13. A VERY vehement heat occasions remarkable changes. A small mass was inclosed in a crucible, made of pure Stourbridge clay, already prepared for forming glass-house pots, having a lid fitted to it of the same materials. The crucible, gradually heated, was kept for forty-five minutes in the intense heat excited by the well managed fire of a smith's forge. At the

the expiration of this time, the crucible itself became soft, and from being turned in the fire was distorted in its shape. On examination after cooling, part of the spar was found to have undergone fusion, and was converted into a glass of a bottle-green colour. The vitrified portion occupied the surface; the internal part was to appearance similar to the result of the last experiment, but it felt much lighter. It now had an acrimonious taste; it attracted water with great avidity, and imbibed it with a hissing noise; it was rendered soluble in this fluid. The loss of weight which the spar sustains when the action of the fire has produced its fullest effect, amounts to 38.79 *per cent.* When a little water is poured on the calcined mineral, it swells, bursts with a hissing noise, and becomes hot with more rapidity and in a greater degree than lime; like it, it falls into a dry powder, but the particles are not so fine.

THE powder unites with acids into the same sort of compounds as before, but no effervescence attends the combination. When the glass is dropped into muriatic acid, it is slowly acted upon; at length a jelly is formed, which becomes perfectly fluid on the addition of water, a minute portion of powdery matter, which probably comes from the crucible, remaining undissolved. If the calcined spar be left exposed to the atmospheric air, in the course of twenty-four hours, it swells, cracks and crumbles into powder, at the same time attracting carbonic acid, and becoming effervescent.

14. UNDER the blowpipe the spar becomes white and opaque, and loses a part of its carbonic acid. I have not been able to vitrify it *per se*. With borax, mineral alkali and microsmic salt, it melts readily into a white vitreous matter. An effervescence attends the fusion, particularly when borax is employed.

15. IT appears from the experiments already recited, that the Strontian mineral loses a greater weight when subjected to heat than during solution in acids. This must be ascribed to the expulsion of moisture in the one case, and the retention of it in the

the other. The difference marks the quantity of water which enters into the composition of the spar. By heat 38.79 per cent. is expelled, while there is a loss by solution of 30.20.

HENCE 100 parts contain of earthy basis,	61.21
carbonic acid,	30.20
water,	8.59

100

16. As I hope to be able to render it probable, that this earthy basis differs from any of the hitherto known species of earth, I shall, to save circumlocution hereafter, take the liberty of calling it by the name of *Strontites*; by which I wish to be understood to mean the earthy matter in a state of purity, in the same way as lime and barytes denote the pure earthy bases of calcareous spar and of aerated barytes.

17. Of the qualities of the *Strontites* it will be proper to add some more particulars.

STRONTITES has a pungent acrid taste. When brayed in a mortar, the subtle powder that arises is penetrating and offensive to the nostrils and lungs. It is soluble in water in the proportion nearly of 2.7 grains to the ounce, at temperature 60. The solution is clear and transparent, possessing a strong taste, not unlike that of lime water; it changes to a green, papers stained with the juice of violets or radishes. On exposure to the air, strontitic water quickly acquires a crust on the surface, in consequence of the earth attracting carbonic acid and becoming insoluble.

18. Hot water dissolves a much larger quantity than cold, and deposits the *Strontites* as it cools in the form of colourless and transparent crystals. The most ready way of obtaining these is to pour a quantity of boiling water into a Florence flask, and then to throw in the recently calcined spar in small pieces. After the ebullition that ensues has ceased, shake the flask well,

and place it so that it shall cool slowly and without disturbance. The crystals will be found attached to the inside of the vessel, shooting beautifully through the water to the length of an inch or more. The form of the crystal is abundantly distinct; it is a thin quadrangular plate, which is sometimes square, though more frequently a parallelogram; the largest of them seldom exceed a quarter of an inch in length, and that is usually somewhat more than their breadth. Sometimes the edges of the plates are plain, oftener they present two facets meeting like the roof of a house. They, for the most part, adhere to each other in such a manner as to form a thin plate an inch or more in length, and half an inch in breadth, the margin being irregular from projecting rectangles, the whole terminated by a regular crystal. Sometimes the plates are thicker, and form solid parallelepipeds, and occasionally are seen perfect cubes.

19. IN the course of exposure to the air for a few hours, these crystals cease to be transparent; they become white, powdery and effervescent. The gain of carbonic acid does not compensate the loss of humidity; for they suffer a diminution of weight which amounts to nearly 10 per cent. To preserve them, we must have recourse to phials very closely corked. When subjected to heat, they lose the superficial moisture with a hissing noise; as the heat approaches to near a dull red, they undergo fusion, which seems to be of the watery kind; for as soon as all the humidity is dissipated, there remains a white powder that resists an extreme degree of heat. Water enters largely into their composition; 100 grains of them lost by the expulsion of the moisture, 68 grains. Water dissolves them but slowly, particularly when they have not been bruised, in the proportion of 8.5 grains to the ounce at temperature 60. An ounce of water, in a heat sufficient to keep the solution boiling, dissolved no less than 218 grains. This is an astonishing degree of solubility in an earthy matter, and affords a distinguishing feature of Strontites. These solutions are possessed of all the

properties of Strontitic water above recounted. In acids the crystals are dissolved without effervescence, and there result the same products as when the native mineral is employed.

20. WHEN I first observed the Strontites in a state of crystallization, I imagined it was the only earth that could, in consequence of its greater solubility in warm than in cold water, be obtained in this form, and I noted this property as characteristic of it. I have however been so fortunate as likewise to procure crystals of barytes.

HABITUDES OF STRONTIAN MINERAL WITH ACIDS.

With Sulphuric Acid.

21. WHEN a solid piece of spar is dropped into sulphuric acid, a few air bubbles arise, but these soon cease, and the mass remains undissolved. If, however, the spar be first reduced into fine powder, and then added to the acid in small portions, an effervescence takes place, a combination is formed, and the compound falls to the bottom. The acid, in very minute quantity, renders Strontitic water turbid, which arises from the formation of the sulphate.

22. THE sulphate of Strontites is in the form of a white powder. It has no taste, and very little solubility in water. I boiled one grain for some minutes in four ounces of distilled water, half a grain was dissolved. The solution became turbid on the addition of the carbonate of potash, of barytic water, and of muriate of barytes. Sulphuric acid, when aided by heat, readily dissolves it. An effusion of water causes the acid to part with the earthy salt.

With

With Nitrous Acid.

23. WHEN the nitrous acid in its strongest state is poured on a mass of native carbonate of Strontites, no action ensues ; but if some water be added, the acid commences to act with energy, and a solution, attended with a brisk effervescence, is the consequence. Very little will be dissolved, though the spar be finely powdered, if the acid be highly concentrated. A small increase of temperature, it may be remarked, enables the strong acid to attack the solid spar, and to accomplish the solution. If you employ an acid previously diluted, the ebullition instantly begins ; for this purpose, an equal quantity of water at least must be mixed with the acid. If much less be added, the effervescence and solution will commence, but they will both soon cease. When the quantity of water is sufficient, the acid free from adulteration, and the spar pure, no residuum is left, and a clear and transparent solution is obtained ; but if somewhat less of the water be employed, the salt that is formed by the union of the acid and earth immediately assumes a solid crystalline form. It was by a solution carried on in this manner that I procured the most regular, though by no means the largest crystals of this nitrate.

24. THE solution has a strong pungent taste. It is perfectly neutral, and readily by evaporation yields crystals. These are rarely produced in so regular a manner that their form can be easily ascertained. By a slow and spontaneous evaporation, crystals were formed that were hexagonal truncated pyramids. The most perfect crystals, obtained in the way a little ago described, were octohedral, consisting of two four sided pyramids united by their bases. Sometimes the apex is truncated, and the crystals terminate like a wedge ; often likewise the angles are truncated in different degrees, which gives a considerable variety to the shape of the crystals.

25. THIS salt is very soluble in water. One ounce of distilled water at temperature 60 dissolved an equal weight. With the aid of a boiling heat, the same quantity dissolved one ounce, seven drachms and fourteen grains. The solution, saturated in a boiling heat, parts not with the salt immediately on cooling, but deposits it slowly in the form of a confused mass of crystals. The nitrate of Strontites in a dry air loses its water of crystallization and effloresces; in a moist, it attracts humidity, and runs *per deliquium*.

26. THIS, as all other nitrates, deflagrates on hot coals. Subjected to heat in a crucible, it decrepitates gently, and then melts. When the heat rises to redness, it begins to boil, and the acid is dissipated. If a combustible substance be at this time brought into contact with it, a deflagration, with a very beautiful vivid red flame, is produced. By the operation of the heat, the salt suffers a complete decomposition, the acid is expelled, and the earth remains in a state of purity, unless inflammable matter has gotten access to it, in which case it will prove a carbonate.

With Muriatic Acid.

27. VERY similar phenomena to those already described, as attending the action of nitrous acid on the Strontian spar, are exhibited on pouring muriatic acid on this substance. When the acid is concentrated, and the spar is in solid pieces, no action whatever, or very little, takes place. The effervescence is brisk, and the solution rapid, when the acid is diluted with about an equal weight of water. A gentle heat, applied to the strong acid, has the same effect as dilution.

28. THE solution in the weak acid is transparent and free from colour, and affords crystals most readily. On dissipating part of the fluid by heat, and permitting the rest to cool, the muriatic salt crystallizes in a beautiful manner. The crystals are

are delicate slender prisms, sometimes two inches long, having a soft silky appearance. If the refrigeration has been very gradual, the prisms will be formed less delicate, and of a more distinguishable shape. All of them are hexagonal, some having all their sides equal, others having two broad sides, with two intervening narrow ones, while another sort is seen with three broad alternating with three narrow sides. At one time they end abruptly, at another an obtuse trihedral pyramid terminates them, and now and then they are seen pointed like a needle.

29. By the facility of crystallization, and by the peculiar form of the crystals, this earthy salt may be easily detected wherever it exists in solution. For this purpose, put a few drops on a plate of glass, and the muriate will soon discover itself by shooting into its long slender needles, which are often disposed in a radiated form.

30. THESE crystals, after they are thoroughly dried, suffer little change from exposure to air, yet when the atmosphere is greatly loaded with moisture, they are apt to deliquesce. Their solubility in water is great. At temperature 60, one ounce of distilled water is capable of dissolving one ounce, four drachms and one scruple. To the same quantity of distilled water, kept boiling on a sand bath, I added in successive portions four ounces of the salt, which became fluid, and I imagine I might have added any quantity more with the same event, as the temperature of the solution, when boiling, seems sufficient to enable the water of crystallization itself to dissolve the saline matter.

31. If into a saturated solution, some strong muriatic acid be thrown, a precipitation instantly happens. The matter that falls down is the salt in small needle form crystals, and the separation of them from the water arises from the force with which the acid attracts the fluid, being greater than that exerted by the salt to retain its solvent.

32. THE

32. THE taste of the salt is peculiar, sharp and penetrating. When urged quickly by heat, the muriate of Strontites undergoes the aqueous fusion, and by losing the water of crystallization, and with it 42 *per cent.* of its weight, becomes a white powder, which, as soon as the crucible is heated to redness, melts. A quantity of this salt was kept in the red heat of a strong open fire, occasionally enlivened by bellows, for above an hour. It had been in perfect fusion, yet its acid was not expelled. It could not, however, when contained in a small spoon of platina placed upon charcoal, endure, without decomposition, the stronger heat excited by the blowpipe.

With Acetous Acid.

33. ORDINARY distilled vinegar dissolves the Strontian fossil, after being reduced to a very fine powder, but with no great energy. An effervescence, as usual, accompanies the dissolution. The liquid acetite is transparent, and without colour. It changes, though slowly, the colour of violet test papers to a green. By spontaneous evaporation, it dries up into a friable salt, composed of minute crystals.

THESE are persistent, though exposed to the atmosphere. They render green the vegetable colours. They seem to be nearly equally soluble in hot and cold water; for a quantity of water, kept in a state of ebullition, which dissolved them at the rate of 196 grains *per ounce*, deposited no crystals on cooling.

With Oxalic Acid.

34. THE Strontian mineral must be in fine powder, else it will remain untouched by this acid. When finely pulverized spar is thrown into oxalic acid, an oxalate of little solubility is generated, which falls to the bottom of the vessel, under the
form

form of a white powder. This acid, poured into Strontitic water, unites with the earth, and precipitates with it.

35. THIS is one of the most insipid, and one of the most insoluble of the combinations into which Strontites enters. Ten grains were boiled in four ounces of distilled water for some minutes, there remained undissolved fully nine grains. The clear liquor had the slightest possible degree of milkiness produced in it, on the addition of sulphuric acid, or of carbonate of potash. By heat the oxalic acid is destroyed, and the earth remains partly pure and partly united to carbonic acid.

With Tartarous Acid.

36. WITH this acid the mineral exhibits appearances nearly similar to those now described. There is however, for a short period, an extremely feeble effervescence. Here I may remark, that for the sake of promoting the union of Strontites with the weaker acids, I frequently employ what I call the artificial carbonate of Strontites, by which I mean this earth precipitated from an acid by an effervescent alkali. On this powder the acid of tartar acts with vigour. When dropped into Strontitic water, it carries down the Strontites in union with it.

37. THE tartrate is nearly insipid. I boiled ten grains of it in four ounces of distilled water; six grains were dissolved. This solution, after it had stood some weeks in a close phial, deposited during frosty weather several small but very regular crystals, the form of which is a triangular table, having the edges and angles sharp and well defined. These crystals undergo no alteration from exposure to the air. When acted upon by heat, they at first swell and are puffed up after the manner of borax, and at length with ignition lose their acid, which is the first change that the powdery tartrate suffers under similar treatment.

With

With Fluoric Acid.

38. SCARCELY any perceivable effervescence happens when Strontian spar is thrown into acid of fluor. It is brisk if the artificial carbonate be used, but little is dissolved, as the fluuate falls to the bottom. Fluor acid occasions a milkiness in Strontitic water by the formation of a fluuate, which is possessed of nearly the same solubility as the preceding.

With Phosphoric Acid.

39. THIS acid attacks the spar, though in a solid form, but the progress of the effervescence and solution is excessively slow. A bit, weighing two or three grains, was not completely dissolved in twenty-four hours, though the disengagement of carbonic acid went on without interruption. The solution continues clear as long as the acid is considerably in excess; but as soon as the point of saturation approaches, it becomes thick, from the deposition of a white powdery phosphate. When the acid of phosphorus is dropped into Strontitic water, a precipitate appears, which is redissolved when the acid comes to be redundant. The phosphate, if perfectly neutral, has little solubility in water. Ten grains of it, treated with four ounces of boiling distilled water, left a residuum of nine grains.

With Succinic Acid.

40. THE acid of amber, dissolved in water, assaults, but with no remarkable activity, the artificial carbonate of Strontites. A clear solution results, which, by spontaneous evaporation, yields a crystalline succinate, which is persistent in the air.

With Acid of Arsenic.

41. THE arsenic acid dissolves with tardiness small but solid pieces of the fossil. With the artificial carbonate the effervescence is lively. In either case, the compound continues dissolved till the acid is almost saturated, when the liquor grows thick, from the deposition of a white powder, which is the arsenicate. A precipitate is formed by pouring Strontitic water on acid of arsenic; but agitation makes it disappear. This happens till the acid is nearly saturated; after which the precipitate will not be taken up, unless upon the addition of such a quantity of acid as shall make it predominate. The arsenic acid being dropped into Strontitic water, a copious precipitate descends to the bottom, which vanishes when the acid comes to prevail.

42. HAVING diluted a quantity of this acid with about twice its volume of water, I threw into it the artificial carbonate to nearly perfect saturation. A clear solution resulted, which evaporated on a plate of glass, gave a gelatinous substance, that by longer exposure to the air dried into a white powder. Crystalline forms showed themselves on the inside of a glass, which contained some of the solution after it had stood for some time. It is somewhat curious, and deserving of notice, that this solution lets fall the greater part of the arsenicate it contains as soon as it is made to boil by the application of heat.

THE arsenicate fully neutralized is only in a small degree soluble in water; an ounce of which, when boiling, takes up rather more than a grain.

With Boracic Acid.

43. To the acid of borax dissolved in hot water, I added a minute portion of artificial carbonate of Strontites; a slight

effervescence and solution took place ; and this happened when similar sparing quantities were thrown in for two or three times, after which the powder united with gentle effervescence, and fell to the bottom. I poured Strontitic water into a similar solution of the acid ; at first no disturbance of transparency was observable, but when the point of saturation was not far distant, a copious precipitate appeared. This I washed with cold water, that seems to act little upon it, and dissolved it in boiling, of which it requires about an hundred and thirty times its own weight. The solution changes to a green, the colour of paper stained with the juice of violets.

With Carbonic Acid.

44. THE combination of Strontites with carbonic acid we have in the Strontian mineral, the properties of which I have been detailing. The earth, soluble in water, becomes scarcely so by uniting with this acid. With an excess of acid its solubility increases considerably, as is the case with barytes and lime. The solution of Strontites is precipitated by water impregnated with carbonic acid, and the precipitate is redissolved by the addition of more of the same fluid.

45. STRONTITES, and all its combinations, possess a remarkable property, and one which I long considered as peculiar to them : I allude to the quality of tinging the flame of combustible bodies of a red colour. The muriate has this power in the most eminent degree. Its effects are well exhibited by putting a portion of the salt on the wick of a candle ; it causes the flame to assume a beautiful deep blood-red colour. All the other compounds, and Strontites itself, occasion more or less of the same appearance. The nitrate approaches the nearest to the muriate ; and it is in consequence of this property that the deflagration of this salt with an inflammable substance exhibits so brilliant and vivid a red flame. It is a pretty experiment to extinguish

tinguish a candle by means of carbonic acid gas, as it issues from a briskly effervescing solution of the spar in muriatic acid. After the nitrate, comes Strontites in crystals; the acetite holds the next place. Those that follow give but a faint tinge of red. I shall enumerate them in the order of their power: Tartrite, sulphate, oxalate, fluat, arsenicate, carbonate, phosphate and borate; the effect of the two last is extremely feeble*.

46. It is worthy of remark, that a certain portion of humidity is absolutely requisite to enable these substances to alter the hue of the flame. By way of illustration, dry by a gentle heat the most powerful of them all, the muriate, and by that bring it to the state of a dry white powder. In this condition it will not affect the flame; moisten it, and instantly you restore its former power. This holds true with regard to all the rest; so much so indeed, that those which have not much moisture in their composition will not affect the flame without an addition of humidity. This is the case with the sulphate, tartrite, oxalate, phosphate, arsenicate, borate, fluat, carbonate and calcined spar. Nay, it is even true with respect to the acetite, though in a crystalline form.

47. ALL the combinations of Strontites with different acids, excepting the carbonate, are decomposed by the three alkalis in their ordinary effervescent state, by virtue, in part, of a double elective attraction. When a solution of carbonate of potash, for example, is dropped into the muriate, at first a transparent gelatinous precipitate is formed, which, upon agitation, after further additions of alkali, acquires a white curdy appearance. Similar phenomena accompany the precipitations by the carbonates of soda and ammoniac; no effervescence attends any of them. The precipitate, when dried, proves to be a white
C 2 subtle

* The beautiful experiment with the muriate was first mentioned to me in the 1787, by an ingenious gentleman, Mr ASH, who was then studying physic at Edinburgh.

subtle powder, and is what I have hitherto denominated the artificial carbonate. In diluted muriatic acid, I dissolved 200 grains of Strontian mineral, and then added salt of tartar, which had run *per deliquium* as long as it occasioned any precipitate. By the test of sulphuric acid, I discovered that the alkali had separated the whole of the earth, which was well washed, and afterwards dried before a fire, being towards the conclusion of the exsiccation brought very near the bars; it weighed 198 grains. This *deficit* of two grains I ascribe to accidental loss, as during washing, by adhering to the filter, &c. The artificial carbonate possesses all the chemical qualities of the native, with this difference, that it parts with its acid more readily when urged by heat.

48. THE prussiate of potash and of lime did not disturb the transparency of a solution of a pure colourless mass of Strontian mineral in nitric acid. Sometimes, however, these substances threw down from solutions in the muriatic acid a sparing precipitate of a blue colour, which denotes the existence of a minute portion of iron in some specimens. The precipitate is most abundant when a coloured spar has been employed; whence I conclude, that the colour which the spar occasionally exhibits is adventitious, and is owing to the iron it contains.

49. WITH sulphur, Strontites combines into an hepar. Equal weights of calcined Strontian mineral and flowers of sulphur were triturated together, and exposed to heat in a covered crucible. The heat was continued till a few minutes after the blue flame had ceased to appear at the chinks of the cover. The mass had been in fusion. Being pulverised, part was thrown into muriatic acid; an effervescence ensued, and the hepatic odour became offensive. Boiling water was poured on the remaining portion; a yellow-coloured fluid resulted, which was decomposed by acids, and gave with acetite of lead a very abundant black precipitate. In the humid way likewise a hepar may be formed. On a mixture of equal parts of flowers of

of sulphur and crystals of Strontites; I poured some hot water, which I caused to boil for some time. A liquid hepar, of a dark yellowish brown colour, was the product, and showed the same qualities as the preceding.

50. CRYSTALS of Strontites were dissolved, but sparingly by alcohol. The tincture was of a yellow colour, and burned with a reddish flame.

51. HAVING detailed all the properties of the Strontian mineral, and of its earthy base, with which I have made myself acquainted, my next object shall be to consider, and, if possible, to determine, whether this earth be really different and distinct from all those that are already known. There are two kinds to which the Strontitic basis bears in its properties no inconsiderable resemblance, I mean barytes and lime; yet it seems to me to differ as much from both of them as they differ the one from the other. In external appearance, it must be acknowledged, some similarity is observable among the native carbonates of these earths. The Strontian fossil resembles most the barytic spar. Indeed this is so much the case, that many persons admitted it into their collections as the aerated barytes. Nay, a French chemist of some note, M. PELLETIER, informs us, that having analyzed a mass, which he received from the Honourable Mr GREVILLE, he did not publish the result, for the reason, "qu'elle ne m'avoit fourni rien de particulier*."

52. THESE two productions of nature agree in exceeding other earthy spars in specific gravity; in retaining their carbonic acid, unless when urged by a very intense heat; in dissolving when caustic in water; in affording the pure earth in crystals; in dissolving in acids with nearly similar phenomena; in forming salts of difficult solubility with several of the acids, and crystallizable ones with the nitric and muriatic. In these respects a strong analogy prevails between them, yet it is but an analogy; for in the points now enumerated,

* Ann. de Chem. t. 10. p. 188.

enumerated, as well as in others, a considerable difference actually prevails.

53. THEIR specific gravities differ, that of native carbonate of barytes being 4.338, while that of Strontitic spar goes from 3.650 to 3.726. The last mentioned parts with its acid somewhat more readily, and without being fused itself, or acting so powerfully on the clay of the crucible; and when calcined, it imbibes moisture with much greater avidity, splitting with more heat and noise. There subsists a greater difference between the solubility of pure Strontites in hot and cold water than of barytes*; moreover, the forms of their crystals disagree widely. Strontites generates with sulphuric acid a less ponderous and more soluble earthy salt than barytes. It is true that both barytes and Strontites form crystallizable salts when combined with nitric or muriatic acids, but the crystals have no similarity either in property or aspect. Those, into the composition of which Strontites enters, suffer changes from exposure to the air, which do not happen to the nitrate or muriate of barytes, and they are vastly more soluble in water. In the figure of the crystals also the difference is very remarkable. A strong and weighty argument in favour of the distinct nature of these earths is furnished by the circumstance, that solutions of Strontites in acids suffer no decomposition from prussiate of lime or potash; for here I put out of consideration the change that is occasionally produced when the minute portion of iron is present; while, as every body knows, a prominent and discriminating feature of barytes is its precipitation by either of these substances. A mark of distinction not less decided is the quality that Strontites and its compounds possess of tinging the flame of combustible bodies of a red colour; a property that does

* I have, since this paper was read, discovered that the difference of solubility of barytes in hot and in cold water is fully as remarkable as that of Strontites. This mark of distinction consequently must be rejected.

does not belong to barytes, the muriate of which gives a very faint greenish hue. To these add, what assuredly carries great weight with it, that these substances do by no means agree in the order of their attractions. On the whole, I think it abundantly manifest, that the fossil from Strontian is not aerated barytes, and that it has not this earth for its basis.

54. It has been above remarked, that this mineral occasionally assumes the appearance of some sorts of calcareous spar; and it has likewise been noticed, that some analogy prevails between the properties of their component earths. In no circumstance does this appear so strongly as in the quality of tinging flame, which I have discovered to belong also to the compounds of lime, though in a much smaller degree. The muriate of lime gives the flame of a candle, when applied in the manner formerly described, a red colour, which is considerably less vivid and brilliant than that produced by muriate of Strontites, and short of that occasioned by the nitrate of this substance. It is easy, however, to show, that Strontites and lime materially differ. The specific gravity of the Strontian far exceeds that of calcareous spar, which is commonly about 2.700. The former retains its carbonic acid much more obstinately in the fire. But the incomparably greater solubility of the pure earth in hot water, and its crystallizing, are characters of themselves sufficient to discriminate Strontites from lime, and I shall only further observe, that Strontites forms a less soluble compound with sulphuric acid, yields a crystallizable nitrate and muriate, and displays a power of attraction different from lime; whence I reckon it certain, that the earth of Strontian mineral is not lime.

55. I NEED not draw a parallel between the appearance and properties of this fossil and any of the other earthy bodies, as it is not in the most distant degree like any of them.

56. It perhaps deserves notice, that the mineral I have been treating of, though different from the native carbonates of barytes

rytes and lime, holds a sort of intermediate space, and forms a kind of link between them. To illustrate what I mean, I may observe, that in specific gravity, fusibility, capability of decomposition by heat, and in the solubility of the compounds it forms, it stands in the middle. Thus, heavier than calcareous and lighter than barytic spar, it is more easily melted than the one, less so than the other. When subjected to heat, it parts with its carbonic acid more readily than barytes, less so than lime. The sulphate, nitrate and muriate of it are all more soluble than the same salts of barytes, and less soluble than those of lime. In one respect indeed it exceeds both, and that is, solubility in hot water, which perhaps is so great as may make some persons, over fond of nice distinctions, deny it a place among the earths altogether*.

57. THIS kind of intermediate situation shall perchance induce some to imagine, that this earth is a peculiar combination of the other two. At first, I confess, when this idea suggested itself to me, I did not deem it improbable; but now, after full investigation, I must reject the notion. This, I hope, I do with good reason, since I have found that, like the acknowledged simple earths, this substance bears repeated solutions, crystallizations and precipitations, without showing the smallest disposition to a separation of principles; and since the means that disunite an artificial mixture of the two earths, such as dissolving in muriatic acid and crystallizing, or precipitating by prussiate of potash or lime, have no effect in occasioning a disjunction of its parts.

58. As the earthy basis of the Strontian spar possesses remarkable qualities that are peculiar to it, and forms with acids combinations unlike those generated by the known earths, and differs from all of them in the order of its attractions, I cannot hesitate to conclude, that it is an earth *sui generis*, a new
2 and

* *Vide* note to 53.

and distinct genus. It belongs decidedly to the ancient order of them called alkaline or absorbent, of which the most abundant species, the calcareous earth, has been long known. To my illustrious master in chemistry, Dr BLACK, we are indebted for establishing the distinct nature of magnesia. Lr GAHN and Mr SCHEELÉ have the merit of discovering barytes.

59. CONSIDERING it as a peculiar earth, I thought it necessary to give it a name: I have called it *Strontites*, from the place where it was found; a mode of derivation, in my opinion, fully as proper as from any quality it may possess, which is the present fashion. My reason is, that I think there is less chance of discovering two new earths in the same spot, than of finding two possessed of the same property any where. The denomination, however, is of little moment, provided it be well understood what it is intended to denote, and there be no room for mistake.

60. To complete the history of Strontites, it remains for me to state what I have discovered respecting the order of its attractions. I shall begin with pointing out the order in which the principal acids attract it, and then I shall show the place due to its attraction among those of other substances for acids.

61. SULPHURIC acid attracts Strontites with the greatest force; for when added to a solution of the nitrate, muriate, tartrate, arsenicate, succinate, fluuate, acetite and borate, it instantly causes a disturbance of transparency, and a white precipitate falls to the bottom. When poured upon the oxalate, which is scarcely soluble in water, and permitted to remain for some hours upon it, this acid expels the oxalic, and takes its place. I may here remark, that the precipitates formed by the sulphuric acid do not descend so rapidly as the ponderous sulphate of barytes; they have oftentimes in their fall more the appearance of sulphate of lime. On this account, Strontites, though a good one, is by no means so delicate a test of the presence of this acid as barytes, nor can it be employed altogether

with the same advantage in the purification of nitric and muriatic acids from the sulphuric.

62. THE acid of fugar, or oxalic acid, follows the sulphuric. This acid takes the new earth from all the solutions above mentioned, and with it falls in a powdery form, excepting from the fluat. It is a curious fact, that the oxalate is soluble in muriatic acid with partial decomposition. I obtained an oxalate by dropping the acid of fugar into muriate of Strontites, which I washed well with cold water, and dried. I then introduced it into muriatic acid, that did not dissolve it till a very little distilled water was added. The solution, in a few hours, had deposited a small quantity of crystals, which I dried on blotting paper. They were persistent in the air, they dissolved in water, and imparted to it the taste of oxalic acid. This fluid was not disturbed in its transparency by sulphuric acid, and it occasioned in lime water a copious precipitate of very little solubility; whence I inferred these crystals were oxalic acid, and their form did not contradict the conclusion. On evaporating the liquor from which they had been deposited, I procured a powdery oxalate and crystallized muriate. The reason of this partial decomposition I cannot at present assign; it cannot be explained in the same way that the partial decomposition of sulphate of potash or soda by nitric or muriatic acid is accounted for.

63. THE third place belongs to the tartarous acid, which decomposes and causes a milkiness in the solutions of the earth in nitric, muriatic, succinic, arsenic, boracic and acetous acids.

64. THEN comes the acid of fluor, which precipitates the earth from its solution in all the acids I have tried, excepting the three already mentioned as exceeding it in force. It is remarkable, that a solution of fluat is not rendered turbid by oxalic acid, though it be certain, that the oxalic has the stronger attraction; perhaps a triple compound is formed.

65. NITRIC

65. **NITRIC** acid holds the next place. When this acid, in a state of concentration, is poured into a saturated solution of the muriate, a precipitate immediately descends. This consists of minute crystals of the nitrate. An affusion of water restores fluidity. The liquor on evaporation affords the nitrate in crystals.

66. **MURIATIC** acid, as usual, succeeds the nitric. As it forms a very soluble compound with Strontites, the decompositions accomplished by it are made apparent by evaporation. The phosphate of Strontites is dissolved readily by this acid. The liquor, when the moisture is dissipated by a very gentle heat, yields crystals of the muriate and phosphoric acid in a concrete state. The arsenicate is taken up still more readily; and from the solution, by an evaporation not pushed so far as to deprive the arsenic acid of its humidity, are obtained crystals of the muriate. The borate dissolved in this acid exhibits phenomena similar to the phosphate. By adding this acid to the acetite, and evaporating, we get the muriate.

SUCCINIC acid, if it do not rank before the two last mentioned acids, without doubt, holds the place immediately following.

67. **PHOSPHORIC** acid comes next in order. It makes no change in the combinations containing any of the acids already noticed, but instantly throws down a precipitate from the acetite, arsenicate and borate. With regard to the two last of these, care must be taken not to add more phosphoric acid than is sufficient, else the precipitate will be instantly redissolved, and will elude observation.

68. **AFTER** phosphoric stands acetic acid, which unquestionably has a feebler attraction than any of the preceding, and I think a greater than the acid of arsenic, because this acid, dropped into the acetite, disturbs not the transparency. Boracic acid follows the arsenic, and last of all comes carbonic

nic acid, which is expelled by all the others, as appears from the narration already given.

Order of Attractions among the Principal Acids for Strontites.

STRONTITES.

Sulphuric acid.

Oxalic.

Tartarous.

Fluoric.

Nitric.

Muriatic.

Succinic.

Phosphoric.

Acetous.

Arsenic.

Boracic.

Carbonic.

69. THE attraction of the new earth for acids ranks high. For sulphuric acid, barytes has unquestionably a stronger attraction than Strontites. I added barytic water to a solution of sulphate of Strontites; and though only an extremely minute portion of this earthy salt be contained in the fluid, yet an immediate milkiness and precipitation was the consequence. This earth however comes next; for I find that, when I pour Strontitic water into solutions of sulphate of potash, of soda, or of lime, the liquor becomes turbid, and the Strontitic sulphate falls to the bottom.

70. I HAVE not ascertained how the attraction of Strontites stands with oxalic acid further than that the force of its attraction for this acid is superior to that of potash, and consequently of all those substances that are inferior to it.

71. THE earth attracts tartarous acid more forcibly than alkalis do. Add Strontitic water to tartrate of potash, and tartrate of Strontites will descend; but its attraction is weaker than that of barytes or lime, for the solutions of either of these earths renders tartrate of Strontites turbid. The same place is due to this earth in its attraction for fluoric acid as with acid of tartar; barytes and lime exceed it, potash is feebler.

72. WITH respect to nitric and muriatic acids, the order seems somewhat different. Here fixed alkalis appear to predominate. Yet of this, after several trials, I was somewhat uncertain, in consequence of peculiar phenomena that occur. When absolutely caustic potash is dropped into a diluted solution of muriate of Strontites, transparent crystalline flakes appear; but long before all the earth is disengaged, the alkali ceases to occasion more precipitation, and it may be afterwards added in quantity, without producing any visible effect. If, however, an effervescent alkali be now poured in, a copious curdy precipitate will be formed. Two hundred grains of Strontian spar were dissolved in muriatic acid. To the solution, diluted with more than an equal quantity of distilled water, I added potash, till it no longer occasioned deposition. I permitted the precipitate to subside, and then poured in some potash, which caused no visible change. The clear liquor was decanted off, and the remaining portion filtered. The precipitate, when collected and weighed, amounted only to 24 grains. With the clear liquor, I mixed carbonate of potash, and I obtained an abundant white precipitate. This I washed, and dried by a gentle heat; it weighed 170 grains. On another occasion, I dissolved a similar quantity of the mineral in the same acid, and after dilution I added the alkali very slowly. The matter separated assumed the form of quadrilateral lamellar crystals, some of which, unattached to any others, showed the wedge-shaped margin like an ordinary crystal of Strontites; frequently they adhered to each other, sometimes appearing in arborescent figures.

figures. I continued to pour in potash as long as any precipitation followed, and I certainly consumed more alkali than would have been sufficient to saturate the whole of the acid. The crystalline deposit, when dried quickly, effervesced very feebly with muriatic acid; it was much more abundant than the former; it weighed 74 grains. From the supernatant liquor, carbonate of potash separated effervescent Strontites to the amount, when dry, of 132 grains. The matter thrown down by potash, when dissolved in muriatic acid, crystallizes in every respect like ordinary muriated Strontites. It is also soluble in water, and generates Strontitic water. From these experiments it appears, that potash precipitates only a portion of the Strontites, which is in the state of crystals, and that this portion is variable in quantity, which I imagine in some measure depends upon the state of dilution. How this comes to pass it is not easy to say. I am disposed to ascribe it either to the production of a triple compound, or to the solubility of Strontites in pure alkali. The weight of the two precipitates, in neither experiment, exactly amounted to that of the spar employed; nor was this to be expected. In the former it was deficient by six grains, in the latter it exceeded by as much. The deficit of the one may arise in part from the loss of matter adhering to the filter, but principally from the heat employed in drying, expelling too much moisture from the first precipitate. *A priori*, it might be imagined, that there should always be a deficiency, since part of the earth is disengaged in its pure state, as invariably happens with lime. Instead of this, however, in the latter experiment there was rather an increase of weight. This I impute to the crystalline form in which the Strontites is separated; for in this state it is united to a greater weight of water than it contains of both carbonic acid and water when it is effervescent.

73. THE impracticability of precipitating all the Strontites from muriatic acid, suggested some doubts whether the alkali

really

really possessed a stronger attraction or not. These were removed by the result of the following experiments: I dissolved a quantity of nitrate of potash in boiling water, and threw in some masses of recently calcined Strontites. The heat generated commenced an ebullition, which I prolonged by the heat of a sand bath, the mouth of the flask being stopped by a perforated cork. During the cooling, crystals of Strontites were deposited. I next dissipated by boiling much of the water of the clear fluid, managing the operation so that the atmospherical air should have as little access as possible. By this process I obtained crystals of nitre, intermixed with a small quantity of crystallized Strontites. I performed a similar experiment with a solution of muriate of soda, and the result only differed in this, that the crystals of common salt were deposited during the evaporation of the liquor, and those of Strontites, for the second time, during the subsequent refrigeration; whence the inference is deducible, that Strontites cannot detach the nitric or muriatic acid from the alkalis with which they are united in saltpetre and sea salt.

74. THE attraction of barytes for muriatic acid exceeds that of the new earth. To a solution of Strontitic muriate I added some native carbonate of barytes lately calcined and reduced to fine powder. Soon marks of decomposition were apparent, and the liquor consisted of muriate of barytes. Muriated barytes, on the other hand, suffers no change from the earth I have been describing. The attraction of lime for this acid is feebler than that of Strontites. Muriate of lime became muriate of Strontites, some time after I had introduced the powder of calcined Strontian spar into it. Ammoniac was instantly disengaged from the muriatic acid by Strontites.

75. POTASS attracts acetic acid more forcibly than Strontites, and dislodges it.

76. PHOSPHORIC acid is one of those that prefer Strontites to alkalis. Strontitic water immediately causes a precipitation

in

in phosphate of potash or soda. Strontites in its turn gives place to lime and barytes.

77. THE same order as in the preceding is observed with regard to the acid of arsenic.

78. BORATE of Strontites suffers no visible change from lime-water or potash, but is turned muddy instantly by barytic water. A solution of borax is decomposed by dissolved Strontites.

79. THE attraction of Strontites for carbonic acid is powerful. It renders mild alkalis caustic, and becomes thereby itself a carbonate. I was desirous of determining the relative attractions of barytes, lime and Strontites for this acid, but found it not an easy matter. The difficulty proceeds from all the three being entirely or nearly equal in power. BERGMAN was not able to decide between the two first of them. In hopes of ascertaining this point, with artificial carbonate of Strontites in subtle powder, I mixed a quantity of barytic and of lime water, and kept them in phials accurately closed. I had the bottles shaken very often during a week. At the expiration of this time, I decanted carefully from both the supernatant fluid, and saturated it with marine acid. The liquor of the one, treated in this manner, gave, on evaporation, muriate of barytes; from the other I obtained muriate of lime. These experiments seem to show, that Strontites will not yield carbonic acid to either of these earths. Again, when Strontitic water, poured upon the carbonates of barytes and of lime, is managed in the same manner as the former, the clear liquors, saturated with the same acid, afford, both of them, muriate of Strontites. This earth consequently had not taken the fixed air from either. Since then neither lime nor barytes can attract carbonic acid from Strontites, and since this acid will not desert either of these to combine with Strontites, I am led to the conclusion, that the forces of their attraction are equal, or very nearly so. This also appears from the following experiments: Into a mixture

ture of nearly equal parts of Strontitic and barytic waters, I threw distilled water impregnated with a quantity of fixed air less than was sufficient to saturate either of the earths. I shook the whole well for some time, in the expectation that the earth, whose attraction preponderated, would attach to itself all the acid, and become insoluble. On examination, however, I found, that the precipitate consisted of the carbonates of both. When a solution of lime, instead of barytes was used, the event was similar.

80. *STRONTITES* precipitates metallic calces from their solutions in acids, but with no particular phenomena. When Strontitic water is poured into a solution of muriate of mercury, a brownish yellow precipitate, like to that produced by barytic or lime water, presents itself. The same fluid causes a dark green precipitate in sulphate of iron, a greyish white in sulphate of zinc, a light blue in sulphate of copper, and a white one in acetite of lead.

TABLE to show the Place due to Strontites in the Order of Attractions.

<i>Sulphuric Acid.</i>	<i>Oxalic.</i>	<i>Tartarous.</i>	<i>Fluoric.</i>	<i>Nitric.</i>
Barytes	Barytes	Lime	Lime	Barytes
Strontites	Lime	Barytes	Barytes	Potash
Potash	Strontites	Strontites	Strontites	Soda
Soda	Potash	Potash	Potash	Strontites
Lime	Soda	Soda	Soda	Lime

<i>Muriatic.</i>	<i>Phosphoric.</i>	<i>Arsenic.</i>	<i>Boracic.</i>	<i>Carbonic.</i>
Barytes	Lime	Lime	Barytes	Lime Barytes Strontites
Potash	Barytes	Barytes	Lime	Potash
Soda	Strontites	Strontites	Strontites	Soda
Strontites	Potash	Potash	Potash	
Lime	Soda	Soda	Soda	

To make a small addition to the history of barytes, and to correct a mistake that has prevailed respecting the native combination with carbonic acid, I beg leave to add a few words.

1. ALL the chemists who have made native carbonate of barytes the subject of their experiments, concur in asserting, that the carbonic acid cannot be disengaged from it by heat alone; and upon this supposed fact, a theory of pretty extensive application has been founded. Dr WITHERING, in his admirable paper, *Phil. Transf.* vol. lxxiv. p. 298. says, "It is very remarkable, that the terra ponderosa spar in its native state will not burn to lime. When urged with a stronger fire, it melts and unites to the crucible, but does not become caustic." "May we not conjecture then, that as caustic lime cannot unite to fixed air without the intervention of moisture, and as this spar seems to contain no water in its composition, that it is the want of water which prevents the fixed air assuming its elastic aerial state." This supposition becomes, in his opinion, still more probable from the circumstance, that the artificial aerated terra ponderosa, which contains water, loses its fixed air by the action of heat.

2. Dr PRIESTLEY adopted this notion, and adds his testimony to the fact upon which it rests. In the *Phil. Transf.* vol. lxxviii. p. 152. we have the following words: "Terra ponderosa aerata gives no fixed air by mere heat. But I find, that when steam is sent over it in a red heat in an earthen tube, fixed air is produced with the greatest rapidity, and in the same quantity, as when it is dissolved in spirit of salt, and making the experiment with the greatest care, I find that fixed air
" consists

" consists of about half its weight of water." From these observations Dr PRIESTLEY infers, that water enters into the composition of fixed air, nay, that it is this ingredient which is essential to the aëriform condition of the acid. He extends the idea to all aërial fluids and hence draws a futile argument against Mr CAVENDISH's glorious discovery of the composition of water.

3. IT is unnecessary to transcribe the words of Mr WATT *junior*, who speaks on the authority of Mr JOSIAH WEDGEWOOD *junior*, to nearly the same purpose, or those of M. SAGE, FOURCROY and PELLETIER who strangely assert, that this substance is absolutely unchangeable by heat.

4. FROM this general opinion, however, I am obliged to dissent, having found, that the fixed air can be expelled from the native aërated barytes by heat alone, if sufficiently intense; a circumstance that must prove fatal to the theory founded on its supposed impracticability. The heat which answers this purpose is that of a smith's forge, when the fire is skilfully managed. By its assistance, I have oftentimes deprived the barytic spar of its acid either entirely or nearly so.

5. I NEED not detail the particulars of more than of one experiment. In several trials, however, it may not be improper to remark, I was disappointed, in consequence of the barytes, vehemently heated, acting as a flux on the clay of the crucible, corroding holes in it and making its escape, leaving as its only vestige a green-coloured vitreous glazing on the inside of the crucible. At first I employed crucibles made of pure Stourbridge clay, but was, from the circumstance this moment mentioned, obliged to have recourse to those composed of black lead, which are able to resist and confine the heated spar; yet sometimes I succeeded even with those of clay.

6. A SOLID and pure mass of the spar, weighing 338.4 grains, was put into a black lead crucible, having a lid of the

same substance fitted to it. The crucible, gradually heated, was kept in the strong fire of a smith's forge for the space of half an hour, when it became very soft. On breaking it after it had cooled, indubitable proofs appeared of the mass having undergone complete fusion. From being previously angulated, it now accommodated itself to the shape of the crucible, and encrusted the bottom and sides of it a little way up. The crust externally, where it slightly adhered to the crucible, was of a dark greyish colour, internally it had a greenish shade. The matter was light, spongy and porous like pumice stone, and being carefully collected weighed only 261 grains. The spar had therefore lost 77.4 grains, which is at the rate of 23 *per cent.* nearly.

7. THE calcined mass imbibed water with a hissing noise and considerable increase of temperature, but without swelling or splitting like lime, and was soluble in this fluid. On dropping it into diluted muriatic acid, a very slight effervescence took place; but this soon ceased, and the dissolution proceeded in perfect quiet. The solution had a greenish cast.

8. FROM another mass, weighing 530.5 grains, I expelled 136.5 grains or 25.60 *per cent.* and still it was not altogether non-effervescent. I however obtained it once absolutely caustic or free from carbonic acid, having employed a crucible of Stourbridge clay, which endures a stronger heat than the black lead. But I could not in this case ascertain the loss of weight, as part of the mass had escaped through a hole it had made for itself.

9. EVEN by the common blowpipe and candle, a part of the acid may be disengaged. Supposing that the heat excited by this instrument, employed in the usual way, would be very inadequate to produce the desired effect, I tried pure air, in the manner I had seen M. LAVOISIER use it. This mode consists in directing a stream of oxygenous gas against ignited charcoal, and

and produces an extreme intensity of heat. By this heat the spar was rapidly melted, but sinking into the pores of the charcoal, it eluded further impresson. I then had recourse to the ordinary blowpipe. The small mass readily melted, and on being kept in fusion for some time, boiled with so much violence as to scatter around it minute particles of the liquid matter. After two or three minutes, it was kept fluid with more difficulty; and, finally, it covered the surface of the charcoal with a thin powdery crust. Though it still effervesced briskly with muriatic acid, a portion of the fixed air had been separated; for a part of it, thrown into distilled water, imparted to it the power of changing to a green violet test-papers, and the water acquired a crust on its surface from exposure to the air.

10. THESE experiments, I hope, satisfactorily show, that the native carbonate of barytes can be decomposed by heat alone, and further afford proof of the insufficiency of the theory that has been deduced from the supposed impossibility of accomplishing it.

11. I HAVE found that barytes is vastly more soluble in hot than in cold water, and that it is deposited from the former in the state of crystals. To obtain these I commonly employ the calcined barytic spar, and the mode I follow consists in throwing into water, that has just ceased to boil, some pieces of a recently burned mass. The heat that is generated causes the water to boil, and I prolong the ebullition for a little time. The clear part of the liquor being decanted off and permitted to cool, deposits sooner or later a quantity of crystals. The shape and appearance of these vary considerably, according to the rapidity with which they have been formed, and this depends upon the greater or smaller quantity taken up by the hot water over what can be retained by it when cold; the most saturated yielding crystals the most speedily, the less so not for several days.

12. THE crystal in its perfect condition seems to be a flatted hexagonal prism, having two broad sides, with two intervening narrow ones, and terminated at either end by a quadrangular pyramid, which, in some cases, constitutes the larger part of the crystal. When the crystallization goes on at great leisure, the crystals are often distinct and solid, of no inconsiderable magnitude; but more commonly with a quicker deposition, they are more slender and delicate, and are attached to each other in such a manner as to assume a foliaceous form of beautiful appearance, resembling some of the fern tribe in their pinnated fronds, to speak botanically; but in this arrangement, a considerable diversity occasionally happens.

13. THE crystals obtained from calcined barytic spar, in the manner now described, dissolve in water, and impart the qualities of barytic water; they change vegetable colours to a green, they unite with acids without effervescence, and generate with the muriatic and sulphuric, compounds similar to the sulphate and muriate of barytes; hence I infer they consist of pure barytes.

14. THESE crystals are perfectly transparent and colourless, but when exposed to the air, become white, opaque and effervescent, losing during this change nearly 30 *per cent.* of their weight. Subjected to the heat of boiling water, they undergo the aqueous fusion and become fluid; from which state, if allowed to cool slowly, they concrete into a solid crystalline mass. When a stronger heat is applied, and continued till all the moisture is dissipated, there remains a white powder, lighter by one half than the crystals employed, which, urged by the heat produced by the blowpipe, is melted with more difficulty than the native carbonate.

15. THE solubility of these crystals in water surprised me a good deal. One ounce of distilled water, at temperature 60, dissolves almost twenty-five grains, while boiling water appears to

be capable of dissolving any quantity of them, however great. This arises from the circumstance, that the earth becomes so extremely soluble at an elevated temperature, that the water of crystallization itself, which scarcely surpasses the weight of the barytes, when heated to the two hundred and twelfth degree, is able to accomplish the solution of the earth without the assistance of more fluid.

16. IN this amazing solubility barytes and Strontites nearly agree, but materially differ from lime, which, so far as I can discover, is dissolved as sparingly by hot water as it is by cold.

be capable of following any quantity of them, however great
This arises from the circumstance that the same becomes to
extremely minute in the air, and the weight of
of which is minute, when it is compared to the weight of the
medium, which is equal to the weight of the air, and is not
it adds to account with the weight of the earth without the air.

And of these things, it is to be observed, that the weight of the
air is not a small part of the weight of the earth, but is
discovered to be equal to the weight of the water in it, by
the following experiment.

Take a glass vessel, and fill it with water, and weigh it
with a scale, and then pour out the water, and weigh it
again, and you will find that the weight is the same.

And if you fill it with air, and weigh it, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other fluid, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other solid, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other substance, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other substance, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other substance, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other substance, you will find
that the weight is the same, as when it was filled with
water.

And if you fill it with any other substance, you will find
that the weight is the same, as when it was filled with
water.

II. OBSERVATIONS *on the* NATURAL HISTORY of GUIANA: In
a Letter from WILLIAM LOCHEAD, Esq; F. R. S. EDIN. to the
Rev. Dr WALKER, F. R. S. EDIN. *Regius Professor of Natural
History in the University of* EDINBURGH.

[Read March 3. 1794.]

DEAR SIR,

ALLOW me at present to trouble you with a few general observations on natural history, which I had an opportunity of making while on a botanical excursion, with my friend Mr ANDERSON, to the Dutch colony of Demerary. Guiana is a country but little known in Europe, though its animals and vegetables have added considerably to the catalogue of natural productions. It is not however the organic kingdom which I mean at present to touch upon; all I aim at is to give you some idea of the face of the country, as leading to the knowledge of its formation and present state. It is not a field for the mineralogist, as its interior is unexplored. But to the geologist, who wishes to trace revolutions of the latest date, it is not uninteresting to contemplate such a recent and singular country as Guiana.

I NEED not inform you, that under Guiana is comprehended all the coast of South America from the Amazons to the Oroonoko; that it trends nearly N. W. and S. E.; that it is in general a very low and flat country, especially the Dutch or westernmost part of it; and that it is watered by several rivers and creeks, which rise in a chain of mountains running nearly E.

and W. and dividing Guiana from the inland parts of South America, which form the banks of the Amazons and its numerous branches.

Coast.—No coast can be more easy to make than that of Guiana. The changed colour of the water indicates soundings long before you make the land, and you may run on in seven fathoms before you can discover it from the deck. The bottom is at that distance a soft mud. All along the coast near Demerary, you have only about two fathom at a good league from the shore; to leeward of Essequibo, it deepens still more gradually. In standing off or on five or six miles, you will hardly deepen or shallow the water as many feet. When a high sea sets in upon such a coast, it is easy to conceive, that at a very considerable distance from the land it must be affected by the bottom. The interval betwixt wave and wave becomes more distinct. As they roll on in succession, the lower part is retarded, the upper surface accelerated, each billow of course becomes steeper and more abrupt, till at last it gradually ends in a breaker, when it has come to the depth of only a few feet. These *rollers*, as they are called, are the dread of seamen, especially betwixt Essequibo and Pomeroon, where the water is shallow, and the bearing of the coast very much north and south, exposes it fully to the action of the trade-winds. In small craft, those acquainted with the navigation do not hesitate to run along the coast, even among the rollers themselves; but vessels drawing from eight to twelve feet water, especially if the swell be heavy and it falls calm, can hardly get off. If anchor and cables fail, they drift on till they are fast in the mud, and there they will continue, sometimes for weeks together, before they go to pieces. The sea-water becomes exceedingly thick and muddy within a few leagues from the coast of Demerary, as much or more so than the Thames is at London. A stranger would naturally take this for the discharge of large
flooded

flooded rivers after a rainy season. By and by I shall explain the true cause of it.

ON approaching the continent of South America, a change on the face of the *sky* will strike the attentive observer. The clouds become less distinct from each other, and the intervals between them less clear. They are blended into one another as it were, and suffused more generally over the atmosphere. They appear to be surcharged with vapour, or to have a stronger disposition to deposit it.

THERE is a particular prevailing appearance of the heavens within the tropics when you are at a distance from continents or very high islands, which has so often struck me that I wonder it has not been taken notice of. I call it a *tropical sky*, and thus describe it. The clouds in fine weather are in a single series or stratum, failing away regularly with the trade-wind. They are small and distinctly separated from each other. The intervals or *sky* above them of a clear azure. The lower surface of the clouds is perfectly horizontal. As the temperature is commonly very equal over the sea, the condensation takes place every where at an equal height from the surface of the water. In the clouds that are over-head, you cannot indeed perceive this; but it becomes more and more visible as the eye recedes from the zenith. The lower limb of each distant cloud appears perfectly level and well defined, brighter than the superincumbent part. At a distance, nothing is to be seen but these limbs closer and closer in gradation one behind the other; and the whole horizon round resembles the roof of a stage, with an infinity of half dropt curtains as far as the eye can reach. In two voyages from Europe, I have met with this tropical sky as far north as Cape Finisterre. It came with a fair wind, which continued with us like a regular trade-wind, accompanied with the same appearance of the clouds, till we made the West Indies. In running down the trade-winds, every one has an opportunity of verifying this description, and must be struck with the beauties

which this sky presents at the setting of the sun. The inhabitants of the lower islands may also be well acquainted with it. In the higher ones, the attraction of the mountains ever forms sets of clouds of other appearances, as being produced by other causes. With our present knowledge of meteorology, hardly any other cause can be assigned for the phenomena above mentioned, than the constant equal temperature that every where prevails on the intertropical seas. One analogous fact however may be mentioned; the exceedingly small range of the barometer in the torrid zone. Does the same cause regulate so exactly the height of the clouds, and maintain the uniform suspension of the mercury? We might almost suspect it did, were it not well known, that the barometer varies as little upon continents, and in the vicinity of mountains, in these regions as elsewhere, though the condensation of vapours is in such cases much more irregular. Upon the continent you will frequently observe this tropical sky also, especially in fine settled weather; but much more commonly you will find the sky there, and even before you make the coast, covered with heavy large dark clouds in some places, and in others, at a greater height, the serene dappled sky, so often seen in Europe.

Winds.—THE *trade-wind* generally prevails all the day long, and on the sea-coast seldom fails even at night; but in less than fifty miles up the river it is a dead calm at night, and the breeze is not able to penetrate so far till towards noon. Still farther up we had whole days of a stark calm, and the heat very intense,

Dews, fogs and temperature.—THE dews, following the law which they generally observe, are very heavy when and wherever there is but little wind, and the hotter the day and evening, they fall the more copiously; they were of course more abundant up the river than near the sea-coast. The exhalations in the day-time
from

from a hot and misty country covered with vegetables being very great, the condensation occasioned by the absence of the sun, and the cold accompanying that condensation, are in proportion. Near the coast the diurnal difference of temperature is but trifling, the constant trade-wind preserving in the air nearly the same medium of heat as in the body of the ocean; but far up the river the range of the thermometer was very great. The heat of the day was intolerable. In the shade it was frequently above 90° . This, when there is no breeze, forces you into the woods for shelter. Towards evening it cools; during the night the cold increases, and is greatest about five in the morning. The thermometer would then be from 72° to 74° . The body of the river being large enough to retain its heat, the evaporation goes on from its surface through the night, and is condensed into thick fog, which hangs over it, and is seldom dispersed before eight or ten next day. While the air was as above in the morning at 72° , the water along-side gave 80° to 83° , and seldom rose two degrees higher at noon-day. We had an opportunity of verifying an observation made by the few inhabitants who live far up the river Demerary, that when it feels very cool in the morning before day-break, they are sure of fine weather; when, on the contrary, it feels warm, they expect rain. They sleep in hammocks, and the houses they have are pervious enough to the air, so they are sensibly affected by any change in its temperature.

Seasons.—As to the seasons, it is not an easy matter, from the accounts given by the colonists, to ascertain them exactly. All seem to agree, that since cultivation has been somewhat extended, they are not so regular as before; that the dry season encroaches on the rainy, and that during the latter, they have often several dry days in succession. The account given by Dr BANCROFT was the one generally allowed; that it is dry about the equinox, and rainy about the solstices; that of consequence they

they have two wet and two dry seasons every year. We thought it difficult to reconcile this with the account given of the seasons of other countries in similar climates, and with what actually takes place in the Carib islands. I will give you my ideas on the subject. It is within the tropics a very general rule, that the vicinity of the sun brings the rainy season. To the northward of the line therefore this must be in our summer months. It is another invariable law, that as in lunar influences, so in the change of seasons produced by the sun, some time is necessary after the maximum of the cause to produce the full effect. The highest tides are not till two or three days after the full and change. The greatest heat of the day is two hours after noon, and the hottest months in Europe are July and August, not June, when the sun is highest. Among the West India islands, the full effect of the sun's vicinity is still later. I have found August, and more especially September, to be the hottest months in the year, and they are accordingly the height of the rainy season. It begins thus: No sooner has the sun come to the northward, and begun to be vertical among the islands in April and May, than his force is felt, the sky is more disturbed, the wind is more frequently from the southward and in squalls, and now and then there are heavy showers. In June the same effects continue, and increase in July, when the proper rainy season may be said to begin, and continues in force more or less till the middle of October. August and September, with part of July and October, when these effects are at their greatest height, are styled the hurricane months, and by the French *l'hivernage*. During them, the full force of the great luminary which distributes light and life, however necessary, seems sometimes too much for nature. She is oppressed and sickens; her respiration is disordered by intense heat; sometimes calms, sometimes heavy squalls; the agitated elements vent themselves in lightning, with thunder and torrents of rain, or are sometimes thrown out into those horrid convulsions, hurricanes,

canes which seem to threaten instant dissolution. Guiana is happily free from these scourges of the Antilles. Their force has lately been partially felt at Tobago, which was thought beyond their reach. In Trinidad, the greatest storms they have hitherto experienced, do not deserve the name of hurricanes; and to the southward, on the main of America, they are utterly unknown. The difference then between Guiana and the islands is this: In the former, the rainy season sets in earlier, as indeed the sun is sooner vertical. Their principal rains are in the end of April, in May, June and July. They are also sooner over; for August, September and October, and I believe part of July, are commonly fair weather. But again, November in part, December, January and February, reckoned dry months among the islands, are in Guiana a second rainy season. The cause of this I take to be as follows: North-easterly winds, pretty stiff, cold, and bleak comparatively in these climates, are frequent among the islands during the winter months. They are well known by the name of Norths. They are often accompanied with rain, but it is not very heavy, nor thought of consequence enough to give the denomination of a rainy season. These winds we know to reach as far as the coast of Guiana; and there I have reason to believe they are productive of more rain than in the islands. The face of a large continent, and its effects upon the atmosphere, may very probably make them give up more of their humidity than they do among the Antilles, though, at the same time, their force and bleakness may not be so much felt. If this conjecture hits the truth, the following ought to be corollaries, and are left to future observation. In this rainy season, when the sun is near the southern solstice, their rains will be with pretty steady northerly breezes on the coast. They may be of longer continuance at a time, but they will not be so heavy as those of summer, and they will be chiefly on the sea-coast, and probably will not extend a great way up the country. It remains even a query with me, whether

whether the rain that accompanies the norths among the islands, especially those most remote from the line, be not generally in a greater proportion than is commonly supposed.

Country.—I WILL now endeavour to give you some idea of the face of the country. Though, as is well known, Guiana is flat and swampy, yet it affords to the attentive eye an interesting variety. The sea-coast is little, if at all, raised above the level of high water, and it continues at this level for many miles inland. It is properly an immense woody swamp, never dry in the driest season, covered with several feet of water in the wet. Next the shore, as far as the brackish water extends, it is covered with mangroves, which grow to a considerable height, and form a thick shade. They are elevated on their branchy intermingled roots from the bare wet clay or mud, on which there is scarcely one herb or plant, but which seems to be all in motion, from the prodigious number of crabs which make their holes in it. Further on, when the under-water is fresh, you meet with a new set of vegetables, principally small trees, which, from their situation, are obliged to adopt the habits of mangroves, having the bottom of their trunks supported three or four feet above ground by their ramified roots. Several climbing plants are mixed with them. Arunis, in great variety and profusion, emerge from the water, or embrace the stems of the trees; and several broad-leafed plants of the hexandria and triandria classes, assist the Arunis in forming an herbage. In all this low part of Demerary, there is not one tree of a large size, nor among them all above two or three species which can be applied to use as timber. Proceeding still up the river, its banks are found generally to raise themselves above the level of the water; and when you have gone up one tide, (betwixt twenty and thirty miles), they are so high, that there is no farther occasion for dams to keep the plantations from being overflowed at high water, as below;

canals.

canals or ditches are sufficient to drain the land, which is still perfectly flat. The trees are here different in species and larger in size than below, and the woods are much more practicable. As they are drier, the ground has acquired a regular sort of surface, and there is neither that plexus of roots, nor the same number of vines, (the common name in the West Indies for all climbing plants), to entangle those who choose to traverse them. The soil here is generally a stiff, cold, reddish clay, mixed a-top with a portion of vegetable mould.

THE sand-hills present to the admiring eye a scene very different from what it had been accustomed to below. The first you meet with upon the Demerary, is upwards of thirty miles from the mouth of the river, and on the right hand ascending, or on its western shore. There are of them further down in the country, but not close by the river-side. This one is the extremity of a ridge which extends to the westward several miles. As you ascend the river, you meet with many more of the same kind on both sides, whose direction seems likewise to be east and west, or nearly at right-angles with the average course of the stream. They vary from 50 to 100, 150, or 200 feet of perpendicular height above the level of the river and the intervening flat country. Their breadth and extent varies sometimes only a few hundred paces, sometimes many miles. Their length is great; with some interruptions, I have reason to believe they are generally continued from one side of the colony to the other, only intersected in different places by the rivers and their branches. They consist of a pure siliceous sand, so white that it dazzles the eyes, commonly fine grained and loose, but not unfrequently mixed with little strata of coarser pebbles, mostly quartz, and sometimes concreted into a proper sand-stone. In the last case, a black or reddish tinge is in many cases communicated to it, from clay, decayed vegetables, or other extraneous matter. There is no regular stratification to be found in it, more than what is common to all

sands, the produce of depositions of different dates, and as they are of different materials, thicker in one place, thinner in another, sometimes horizontal, but oftener inclined, and convex or concave according to circumstances. We could meet with no appearance of shells or other marine productions, but in a few places, pieces of broken vegetables buried in the sand where it was concreted. They were black as all the fossil vegetables that I have ever seen in sand-stone. Upon, and by the sides of the sand-hills, grows the most valuable timber of these colonies. The trees there are of a good size, and very clear of obstructing underwood or vines. The Wallabba, (*Parivoa grandiflora* of Aublet); the Sipiri or green-heart, (a new species of laurel); the Coumarou or Tonquæbean-tree, *Coumarouna odorata* of Aublet; the Mora, valuable for boat-timbers, and many others, whose wood is equally hard and beautiful.

CONTINUING to ascend the river, the sand-hills become rather more frequent, but the intervals still remain a perfect flat, though now several feet above the level of the stream, and the soil is still a stiff clay. Hitherto the river is deep all over, generally from two to five fathoms; the bottom is mud or clay, and the shores on either side at low water covered with ooze. About 130 miles up, however, or just before it begins to shallow, the bottom is covered with banks of a hard white or brown sand. It was a problem for some time whence all this sand originated in such a country. It was soon solved. Leaving here the vessel that had hitherto carried us, we proceeded in a canoe; and at about 160 or 170 miles distance from the mouth of the river, we met with the first proper hills of solid materials. The nearest to us was a rock of granite projecting into the stream, whose direction it gave a change to at this place, and it served for a landing-place to the highest piece of cleared land upon the river next to the post-holders. It was part of a low ridge of the same stone which crossed the country, probably to Berbia or beyond it, and was succeeded by many other series of hills

hills more inland, and as far as we could examine them, of the same materials. The granite was both of the red and the gray kinds, but chiefly of the latter. A number of seams or dikes crossed it here and there in all directions, not distinctly separate, but firmly united to the rest, making as it were but one body with it, and consisting of the same materials differently modified. Their component parts were generally smaller; they were more compact and closer in the texture than what surrounded them; and where they had been equally exposed to the action of the weather, they appeared to have borne it much better than the surrounding granite. The origin of the sand was now accounted for. This stone, in some cases exceedingly firm and durable, is in others very liable to decay; and the wash of these enormous chains of hills was able to furnish abundance of such sand as we had met with below. The granite afforded many varieties, indeed every shade, from large and distinct grained, to that whose component parts of felspar, schorl or quartz, were so small as to resemble pretty compact, compound lavas, or some of our mixed whin-stones in Scotland. All these varieties would be found at no great distance from each other. I brought some specimens, from Tiger's berg, a hill about 500 feet perpendicular height, which have every appearance of having undergone the action of fire. They resemble half-vitrified scoriæ, and would be taken for them, but that they were actually broken off from the granite, and discover all its parts in the fracture. The summit of this hill is irregular, with several pits and holes among the rocks. A little higher than it, and I suppose nearly about 200 miles from the sea, you meet what are called *the Falls*. They are only five or six rapids, within the space of a mile or two, formed by ledges of very close-grained gray granite that run across the river. There are breaks in each of them, through which the dextrous Indians are able, in their light canoes, to pass up at any season, even the driest; and when the river is swelled by

the rains, they become totally obliterated. Two days journey, or two and a half above this, is the great fall, where the stream comes over the face of a rock, as we were informed, twenty feet high.

Savannahs.—SAVANNAHS, ever since the discovery of America, have been known to occupy large spaces in the southern parts of that continent. They are to be met with abundantly in Guiana, and are of two kinds very distinct from each other, the *wet* and the *dry*. Of the former, many are extensive as the eye can reach, immense verdant plains occupying the whole face of a country, with or without a few straggling insulated patches of wood. In the dry season, they appear meadows of long grass or reeds, and are seldom practicable for any distance, for the bottom is very rarely dry. In the wet season, they are all one entire plain of water, over the surface of which the grass still rises, but which may be every where navigated in the courials or canoes. Towards the end of the drought, the Indians set fire to them. The young growth which succeeds attracts the deer, and the native, on the return of the half-deucalion days, pursues them in his little bark across their former plains. The soil upon these savannahs can neither be very deep nor very good; yet water may be always commanded, and labour and industry might convert these deserts into *rice-fields*. It is a question whether the days of slavery will ever see that event. The culture of this useful vegetable, which in the east has for ages been the standing food of millions, brings too moderate a return, at least in an infant colony, for the rapacious agricultural system of the West Indies.

THE *dry* savannahs are neither so frequent nor so extensive, yet we have passed through some of them several leagues in circumference. They are formed along the flats on the top of the sand ridges, and covered by a very thin coat of verdure. They resemble, exactly enough, some of the bare moors in Scotland.

Many

Many beautiful plants of the class gynandria are their chief ornaments, as is also the orchis, which grows in similar situations with you. Some Melastomas, and more Rhexias, supply the place, and bear somewhat of the habit of the Ericæ; for your Sedums and Saxifrages is the little Sauvagesia; and in hollows of the same savannahs, where moisture prevails, what I never could have expected to see within five degrees of the line, and not more than 50 or 100 feet above the level of the sea, the Drosera lifts its humble head from a bed of the Sphagnum palustre.

BESIDES these two kinds, there are also what we may denominate *half-savannahs*, formed upon the tops of sand-hills, higher and more irregular than in the case of those just described. Some of these are also very extensive. Few herbaceous vegetables are to be met with upon them. Broad spaces of arid sand are intersected by clumps of shrubery. Nothing grows to the height of a tree; but a particular set of plants, different from those in other parts of the country, find subsistence enough to rise to fifteen or thirty feet. How nature, after all her efforts, should have failed to induce a soil upon these, is surprising. It appears chiefly owing to the great porosity of the sand, which every where admits the decayed vegetable matter destined for that purpose, to be carried down through it, and filtered off by rain. Even those sand-hills which are covered by tall trees, still shew proofs of this. The trifling layer of mould formed upon them is exceedingly thin. When cleared they are very barren; and when you dig in them to a great depth, you still find small portions of black vegetable earth dispersed among the sand. What corroborates the above supposition, is the appearance of the springs. Abundance of these are found gushing out copiously round the verges of the hills; and notwithstanding the extreme whiteness and purity of the sand from whence they flow, there is not one in an hundred whose waters are limpid. They come out not muddy, but of a brownish colour, very much like the water which runs from
peat-

peat-mosses, and they are certainly tinged by the same cause. The rotten leaves of trees, and other decayed parts of vegetables on the hills, instead of being collected on the surface to form soil, are washed down into the sandy strata by every rain; so that the reservoirs of the springs, and the water which proceeds from them, is always coloured with these substances. There follows a corollary also from this general principle, and when compared with facts I believe it will hold good: The more the sand is concreted into stone in any of the hills, the more and better will be the soil upon them. Where clay in small beds, or in a certain proportion, is mixed with the sand, the vegetable mould will likewise be better retained.

Rivers.—I WILL next give you what general observations I have been able to make upon the rivers and creeks of this part of America. The course of nearly all those of Guiana is from south to north. They originate in a chain of hills running east and west, which separates Guiana from the country on the Amazons, and likewise gives rise, on its south side, to the numerous branches which fall into that river. The Demerary is a considerable stream, equal, if not superior to the Thames; yet it is by no means among the largest of them. The Essequibo is five times larger at its mouth, forming a whole Archipelago of islands; but its stream soon divides, and, on account of rocks, shallows and rapids, none of its branches are navigable so high up as the former. Most of the particulars I am now to give you must be understood as applying to the Demerary. The bar, if it may be so called, is common to this with many other rivers, which discharge themselves into a shallow sea; but still with circumstances in the present case which distinguish it from others, where the bottom is not mud but sand. It does not run like a single narrow ridge, across, or nearly across the mouth of the river, but it is of great extent, and is properly a continuation of the mud-bank which runs all along the coast. To the east and west, and for two miles or more in the offing, you have

have ten or twelve feet water with the utmost uniformity, and standing in with the mouth of the river open, you neither deepen nor shallow till you enter it, when you find two, three, four or five fathom, and it continues to average that depth for a long way, so that any vessel which can enter, may, for draught of water, proceed up the river for 100 miles or more.

THE mouth of the Essequibo, from the sand-hills and rocks being very near it, is exceedingly different. Three large islands present themselves in a breast, and divide its entrance into four channels. The length of these islands is with the current, south and north; and from the tail or north end of each of them, as also from the banks of the main on either side, run out sand-banks to a good distance. They are perfectly firm, quick in very few spots, and the body of them is above the level of low water. On the outside of them you have the continuation of the mud-banks and shallow water as above, only that the entrance of these channels is still shallower than that of the Demerary. The stream of this river runs very brown and muddy, and the sea is stained with it for some leagues off. A stranger naturally imputes this to the washings of a large flat country, or the stirring up of the muddy bottom by the tides. The latter may in part be a cause, though I believe it contributes to it but very little, and the former, in a state of uncultivation, none at all. On ascending forty miles or so, you find the water clear again, or rather of a darkish hue, and so it continues above that. I was at first at a loss how to account for this, but, from a number of circumstances, was soon led to conclude, that the thickness, and light brown colour of the water near the mouth of the river and on the coast, were almost entirely the effect of cultivation. Numberless ditches and canals have been opened by the inhabitants, which are receiving or discharging water every tide, and each particular piece on a plantation is every way intersected with open little drains, which communicate with these ditches. In digging and hoeing this clayey soil, much of it is suspended in:

in the water, and carried off by the current of the tides. Nothing can be more certain, than that all up the river, and in all the creeks which discharge themselves into it, the colour of the water is constantly clear or blackish, even in the rainy season, when it is swollen. On considering these circumstances, I have been led to this general conclusion, which is submitted to the proof of observation in different parts of the world. The reddish brown colour, so common in freshes of rivers, in Europe, and we may add every where, is almost entirely the effect of cultivation; and the natural colour of rivers, even in the highest and longest continued floods, where all the country is still in woods or pastures, is ever that of a very dark brown, or blackish, pretty much like that of the streams which rise among peat-mosses, but rather more diluted. It is comparatively very clear, and deposits but a trifling sediment. The other is thick and opaque, and its sediment copious. Thus is man, in his little workings, made, in a small degree, one of the engineers of nature. We cannot doubt, that entire strata will owe to him their existence, accumulated in a series of ages at the bottom of the sea, and destined, in future revolutions, to act a more distinguished part. It may be curious too to consider the differences that may be expected betwixt the strata formed by these different depositions, which may be supposed between them to have been the origin of most of the clays upon our globe. Clay, earth or loam, stirred up by the labourer, gives rise to the one; minutely decayed parts of vegetables form the body of the other.

It must also be observed, that clearing the ground along the coast, by cutting down the trees, and opening ditches for the discharge of water, has exposed the land very much to the washing of the sea. The roots of the mangroves formed a plexus able to resist its force; and the former equal, and very slow deepening of the water, prevented its making a strong impression

impression on any place. The discharge from the ditches at low water cut out channels in the mud, and left the sides of these channels more exposed to the returning waves, which here beat continually upon a lee-shore. We find therefore on the coast, that the sea has made here and there considerable encroachments, which generally begin on the west side of the canals or ditches, as being the most acted upon by the waves. The mouth of the Demerary itself furnishes us with a strong instance. That river is now nearly twice as wide as it was when the country first began to be cleared; the sea and the stream together having since that swept away a large portion of land from the western shore.

Creeks.—A NUMBER of creeks fall into the Demerary on both sides, but so small that they bear no proportion to the size of the river. You can hardly distinguish their mouths in the woods which overhang the banks. They are so narrow that it is difficult to run a small boat in them; yet you will find in them throughout from two and a half to four fathom water, and they run winding so far back that it will take five, six, eight hours, or more, to carry you up to their heads, where they terminate in small streams from among the sand-hills. The banks of the creeks at their mouths are of the same height as those of the river close by, from five perhaps to twelve feet above the water in the dry season. As you ascend the creek, you might naturally expect to find them rise. It is however the very reverse; they become gradually lower and lower, till at last all round them is a swamp; and the trees on each side in like manner become smaller and smaller, and of different species from what they were. It is now in short exactly a mangrove swamp, with this difference, that the water is quite fresh, the vegetables are not the same, and there are abundance of arums and other low herbaceous plants. A little higher up,

you lose the wood altogether, and find yourself in a beautiful deep canal, winding through a spacious wet savannah, which is sometimes many leagues in circumference. The first time we went up one of these creeks, (called Camouni), I was surprised at this appearance, and thought it must be a mere local circumstance peculiar to it. We found afterwards the same in one or two more instances, and were satisfied upon enquiry, that it is common to them all. It was natural to look for an explanation of this phenomenon, and I soon found it in one of those laws, which probably extend to all rivers subject to frequent inundations. It has been observed, in particular, of the Ganges *, that the banks of that river are higher than the adjacent lands at a distance from the stream, owing, no doubt, to the annual depositions of mud, &c. during the swell of the river. Apply the same rule to the Demerary, and the difficulty will be solved. The wet savannah behind, and the swampy woods around them, are the body of the low country at its natural level, scarcely a foot or two above the sea. Whatever additional height the land has in the vicinity of the river, from the time you have ascended about twenty miles or so, is all acquired. It has arisen from the sediment of the river during the rainy season, when the country is overflowed so as that all the lower part of it is under water. This deposition must be always more copious, in proportion as it is nearer the stream, where additional quantities are always brought, and where it is kept in motion both by the current and the tide. Every thing which we afterwards saw confirmed this theory, and nothing more directly than the canals which run out at right angles from the river. Some of these extend four miles inward, and they prove to a demonstration, that the land becomes lower and lower the farther you recede from the

the

* Account of the Ganges, &c. Phil. Transf. 1781, by M. RENNELL.

the river. The maps of the colonies confirm it; for in all of them the main body of the low land of Guiana is laid down as savannah, and the woody country, which a stranger or superficial observer would suppose to be the whole or much the greater part of it, is in fact only a border on the sides of the rivers and of the sea, but of considerable breadth, more or less, in proportion to the size of the adjoining river, or, which is generally the same thing, to the acquired height and extent of the soil on either bank. It followed as a consequence, and, as far as we had opportunities of observing, we found it to be the case, that the low land was somewhat higher, and continued so farther down, about the Essequibo than the Demerary; the woods consequently were of greater extent. We found, besides, in the soil adjoining the Essequibo, at least upon the east side, a mixture of sand. The river is full of sand-banks; and it appears, that the finer parts of even this less suspensible substance are raised by the floods and carried among the adjacent woods to be deposited with the mud. The Mahayka, a small river or creek which falls into the sea about twenty or thirty miles to the eastward of the Demerary, though it runs a long way up the country, and spreads into many branches, has but a very narrow, and often interrupted border of wood upon its banks; it runs through an immense savannah, and so do its branches, with little or no wood, till they approach the sand-hills. The Deltas of the river of Oroonoko, and its numerous mouths, make a figure even in the map of the world. It is to be regretted, that its noble stream has been so long hid from science. What I learned in Trinidad from a gentleman, who had sailed from its mouth to the Angusturas, about 300 miles up, confirms and illustrates, in the fullest manner, the above general rule. The western mouths of it opposite Trinidad, are navigable only for launches drawing six or seven feet wa-

ter. At and opposite them, the bottom is shallow and muddy, and the coast a low mangrove swamp, resembling, in all respects, that of Guiana. You must ascend those branches several days before you reach the main stream; and in doing so, you find the same phenomena as in ascending the Demerary, but in a still greater degree. At first you have the mangrove, or some similar swamp, and behind it on both sides for about twenty leagues, the land, if you can call it so, hardly emerging from the water. Afterwards the ground appears; and, as you go up, rises still higher and higher on the banks above the common level of the stream. The trees become, in the same manner, of different species, and much taller than they were below. The channel in which you are, from being wide, grows narrower by degrees. It is from about one and a half to three-fourths of a mile broad near the entrance; and, when it joins the main stream, is not more than about 200 yards. It has then acquired a considerable depth, and the banks may be about twenty feet high. Along the main stream of the river, or Boca de Nafios, the gradual rise, and other circumstances attending it, are quite similar. All this height of the bank, I can make no doubt, is entirely acquired ground, formed by the sediment of the floods, greater near the streams than at a distance from them; and though I have no knowledge of the nature of the land in the deltas and their vicinity, I would not hesitate to say, that great part of the interior body of each island, and most probably of the main on either side, where it is low country, consists of nothing else than wet savannahs.

Floods.—BEFORE we leave the rivers, it may be proper to take notice of their *floods*. In no instance of a large river does the universal law within the tropics fail, that they annually overflow their banks for a certain season. What was a prodigy
in

in the Nile during the infancy of science, is now a well known phenomenon to every inhabitant of a continent in the torrid zone. From the situation of the river Amazons, it amounts to a certainty, that the Demerary, Essequibo, and other rivers of Guiana, cannot originate very far up in the continent of South America. This is confirmed by what I could learn of the rise and duration of the floods of these two rivers. Enquiring about them at the plantations below, is to little purpose, for there the floods are hardly discernible; but by the postholder and the settlers farthest up, I was informed, that they are there sensible enough, and that, independent of all partial swells from accidental rains, the Demerary generally rose every year in the month of June, and continued high through July and part of August. The rise there, upon the whole, might be about twelve feet; it is sufficient to lay the level parts of the country under water, and to render the woods, that cover them in several places, passable in canoes. We could have wished for more exact information. This, however, was sufficient to prove, that the rivers did not rise very far inland, else the floods would have been later in the year; but at the same time that they were of extent enough to follow the rule of all considerable intertropical rivers, so as to have a flood in the rainy season, that is, in the months when the sun is upon the same side of the line on which they have their origin and course.

THE great Oroonoko, I have been informed, begins to rise a little in May, it continues increasing through the summer months, and the inundation is at its height in September. At that time, as far up as the Angusturas, the rise is about forty feet perpendicular above the low water-mark. It diminishes as you descend till about the month, where it is only a very few feet.

Tides are of the utmost consequence to the inhabitants of the coast of Guiana. They enable them to drain a country which otherwise could never have been cleared, and they ascertain their journeys which are made by water up and down the rivers, and even along the coast. At the mouth of the Demerary, it is high water at about half past five, at new and full moon. The rise in spring tides, a little way up, is twelve feet, or more, above low water-mark. The tide runs very rapidly near the mouth of the river, seldom less than four or five miles in the hour. It continues to run with force for a long way up, and was sufficient, without wind, to carry us up or down at 150 miles from the mouth. Above that it becomes feebler; and for a considerable distance below the rapids, though there is a sensible rise and fall of two or three feet, yet, even in the dry season, the current is constantly down, only more gentle during the rise or flood, and there also the continuance of the rise is very short, not more than two or three hours.

SOME observations upon the *Soil* of the different parts of the country, may be the subject of a future communication. I will only add at present, what I think has more than conjectural foundation, *viz.* That this most recent of countries, together with the large additional parts still forming on its coast, appear to be the productions of two of the greatest rivers on the globe, the Amazons and the Orooneko. If you cast your eye upon the map, you will observe from Cayenne to the bottom of the gulph of Paria, this immense tract of swamp, formed by the sediment of these rivers, and a similar tract of shallow muddy coast, which their continued operation will one day elevate. The sediment of the Amazons is carried down thus to leeward (the westward) by the constant currents,
 2 which

which set along from the southward and the coast of Brasil. That of the Oroonoko is detained, and allowed to fettle near its mouths, by the opposite islands of Trinidad, and still more by the mountains on the main, which are only separated from that island by the Bocos del Drago. The coast of Guiana has remained as it were the great eddy or resting-place for the washings of great part of South America for ages; and its own comparatively small streams have but modified here and there the grand deposit.

W. LOCHHEAD.

III.

which let along from the forehead and the rest of the face. That of the Orisole is detached and allowed to fall down, moving by the edge of the forehead, and this way by the prominence on the brain, which are only separated from the brain by the bones del Duro. The rest of the brain is retained as it were the great eddy or rolling place for the washings of great part of the brain, and as the compoundly small brains have but modified parts and there the great eddy.

W. LOCKHART

III. *A short Paper on the PRINCIPLES of the ANTECEDENTAL CALCULUS.* By JAMES GLENIE, Esq; M. A. F. R. S. LOND. & EDIN.

[Read Dec. 1. 1794]

SEVERAL of my friends have suggested to me the propriety of publishing something of the kind now offered to the Society, observing, that the great brevity with which the *Antecedental Calculus* is written, and the very concise form in which it is delivered to the public, may lead some to form erroneous opinions respecting the principles on which it is founded. In compliance partly with their request, I have drawn up this short paper, which I hope will remove even the possibility of misconception on that head, and convince every intelligent reader, that the antecedental calculus has the same geometrical principles for its ground-work, that the formulæ in the *Universal Comparison* themselves have, from which I originally derived it more than twenty years ago.

IN the third page of that treatise, I have shewn from the first formula in the third theorem of my *Universal Comparison*, that, when R and Q are any two given magnitudes of the same kind, and A, N, B are any homogeneous magnitudes, the excess of the magnitude, which has to B a ratio having to the ratio of A+N to B the ratio of R to Q, above the magnitude,

VOL. IV.

I

which

which has to B a ratio, having to the ratio of A to B the same ratio of R to Q, is geometrically expressed by

$$\frac{\frac{R}{Q} \cdot A \cdot \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \cdot \frac{R-2Q}{Q} \cdot N^2 + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot A \cdot \frac{R-3Q}{Q} \cdot N^3 + \dots}{B \frac{R-Q}{Q}}$$

or, which comes to the same thing, that the expression,

$$\frac{A \frac{R}{Q} + \frac{R}{Q} \cdot A \cdot \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \cdot \frac{R-2Q}{Q} \cdot N^2 + \&c.}{B \frac{R-Q}{Q}}, \text{ exceeds the}$$

geometrical expression, $\frac{A \frac{R}{Q}}{B \frac{R-Q}{Q}}$, or

$$A + \frac{R-Q}{Q} \cdot A \cdot \frac{A-B}{B} + \frac{R-Q}{Q} \cdot \frac{R-2Q}{2Q} \cdot A \cdot \frac{A-B}{B}^2 + \&c. \text{ by the afore-}$$

said geometrical expression.

IN the same page, I have shewn, that the excess of the magnitude, which has to B a ratio, having to the ratio of A to B the ratio of R to Q, above the magnitude, which has to B a ratio having to the ratio of A—N to B the ratio of R to Q, is geometrically expressed by

$$\frac{\frac{R}{Q} \cdot A \cdot \frac{R-Q}{Q} \cdot N - \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \cdot \frac{R-2Q}{Q} \cdot N^2 + \&c.}{B \frac{R-Q}{Q}}, \text{ or, which comes to}$$

the same thing, that the expression,

$$\frac{A \frac{R}{Q}}{B \frac{R-Q}{Q}} \text{ or } A + \frac{R-Q}{Q} \cdot A \cdot \frac{A-B}{B} + \frac{R-Q}{Q} \cdot \frac{R-2Q}{2Q} \cdot A \cdot \frac{A-B}{B}^2 + \&c. \text{ ex-}$$

ceeds

ceeds the geometrical expression,

$$\frac{A \frac{R}{Q} - \frac{R}{Q} \cdot A \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{Q} \cdot A \frac{R-2Q}{Q} \cdot N^2 - + - \&c.}{\frac{B \frac{R-Q}{Q}}{Q}}, \text{ by the}$$

aforesaid geometrical expression.

It is almost unnecessary to observe, that the two expressions, which have respectively to B ratios, having to the ratios of A+N to B, and A-N to B the ratio of R to Q, give us

$$\frac{A \frac{R}{Q} \pm \frac{R}{Q} \cdot A \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{Q} \cdot A \frac{R-2Q}{Q} \cdot N^2 \pm + \&c.}{\frac{B \frac{R-Q}{Q}}{Q}} \text{ for the geo-}$$

metrical magnitude, which has to B a ratio, having to the ratio of A±N to B the ratio of R to Q. But as this expression must vary indefinitely with the endless variations in the quantity of the magnitude B, its geometrical standard of comparison, so, when we suppose it to become numerical, we get an indefinite number of arithmetical formulæ, referring to different standards of comparison. For B may be then represented by

$$1, 2, 3, 4, 5, \&c.$$

$$1, \sqrt{2}, \sqrt{3}, \sqrt{4}, \sqrt{5}, \&c.$$

$$\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, \frac{1}{6}, \&c.$$

$$\text{or } \&c. \&c. \text{ fine limite.}$$

And in that particular case, when it is represented by 1 or unit, this geometrical formula gives the arithmetical one, (putting *r* and *q* for R and Q.)

$$A \frac{r}{q} \pm \frac{r}{q} \cdot A \frac{r-q}{q} \cdot N + \frac{r}{q} \cdot \frac{r-q}{q} \cdot A \frac{r-2q}{q} \cdot N^2 \pm \frac{r}{q} \cdot \frac{r-q}{q} \cdot \frac{r-2q}{3q} \cdot A \frac{r-3q}{q} \cdot N^3 + \pm \&c.$$

which

which has to 1, or unit, a ratio having to the ratio of $A \pm N$ to 1 the ratio of r to q . In it A , N , r , q , may be any numerical or arithmetical magnitudes whatever, whole, fractional, furd or mixed. This formula, or antecedent, is exactly what is commonly called the Binomial Theorem.

If we suppose B to be represented by 2, we derive immediately from this geometrical antecedent or formula, the following arithmetical one :

$$A \frac{r}{q} \pm \frac{r}{q} A \frac{r-q}{q} N + \frac{r}{q} \cdot \frac{r-q}{2q} A \frac{r-2q}{q} N^2 \pm \frac{r}{q} \cdot \frac{r-q}{2q} \cdot \frac{r-2q}{3q} A \frac{r-3q}{q} N^3 + \pm \&c.$$

which has to 2 a ratio having to the ratio of $A \pm N$ to 2, the ratio of r to q .

To such arithmetical formulæ there is no end or limit. And this I take to be the true and systematic method of deriving them, *viz.* from geometrical antecedents or formulæ, when they are supposed to become numerical.

WHEN 1 or unit is the standard of comparison, its various combinations with itself and the other numerical magnitudes, do not appear in the formula or antecedent. This circumstance renders it of all others the most commodious for common use in algebra and arithmetic, though the least calculated of any for shewing the rationalia or ground-work of the various operations in these two sciences. For when the formula or antecedent shows the different combinations of the consequent or standard of comparison with itself and the other numerical magnitudes, it is a sort of language announcing or exhibiting the reasons of its formation.

It is evident, that half the excess of the two geometrical expressions taken together, which have respectively to B ratios, having to the ratios of $A \pm N$ to B and $A - N$ to B , the ratio of

R to Q , above twice $\frac{A \frac{R}{Q}}{B \frac{R-Q}{Q}}$, or twice the magnitude, which

has

has to B a ratio having to the ratio of A to B the same ratio of R to Q, is truly expressed by

$$\frac{\frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \cdot \frac{R-2Q}{Q} \cdot N^2 + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot \frac{R-3Q}{4Q} \cdot A \cdot \frac{R-4Q}{Q} \cdot N^4 + \&c.}{B \frac{R-Q}{Q}},$$

and that half the difference of these expressions is

$$\frac{\frac{R}{Q} \cdot A \cdot \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot A \cdot \frac{R-3Q}{Q} \cdot N^3 + \&c.}{B \frac{R-Q}{Q}}.$$

BEFORE I proceed farther, however, in the consideration of these expressions, it may not perhaps be improper to premise the few following lemmata, which are almost too evident to require demonstration.

LEMMA I.

If any ratio be compounded with its inverse, or the inverse of any ratio the same with it, the composition produces a ratio of equality.

FOR of the three magnitudes A, B, A, by the definition of compound ratio, (5. EUC. SIMSON'S edit.), the ratio of A to B, compounded with the ratio of B to A, is the ratio of A to A, or a ratio of equality; and if the ratio of C to D be equal to, or the same with the ratio of A to B, its inverse, D to C, is equal to, or the same with the ratio of B to A, (Prop. B. *ibid.*): Therefore, (Prop. F. EUC. 5. SIMSON'S edit.), the ratio of A to B, compounded with the ratio of D to C, is the same with the ratio

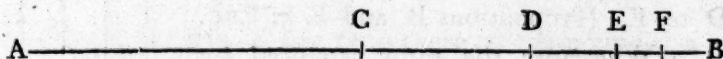
Q. E. D.

[illegible]

SECONDLY,

LEMMA IV.

IF from any magnitude there be taken the half, and from the remainder its half, and so on, the halves so taken, be their number ever so great, are together less than the magnitude.



FOR let AB be any magnitude, AC the half of AB, CD the half of CB, DE the half of DB, EF the half of EB, and so on.

THEN it is manifest, that AC, together with CD and DE and EF, &c. are less than AB, from which they are taken. Q. E. D.

COR. 1. The ratio of AB to the successive halves AC, CD, DE, EF, &c. taken together, be their number ever so great, is greater than a ratio of equality; and the ratio of any one of the terms to all the succeeding ones taken together, be their number ever so great, is greater than a ratio of equality.

COR. 2. Hence it follows, that of any series or succession of terms, in which the half of each term has to the immediately succeeding one a ratio of equality, each term has to all the succeeding ones, be their number ever so great, a ratio greater than that of equality.

COR. 3. Hence it also follows, that if CD, instead of one half, be one third of AC or CB, DE one fourth of CD, EF one fifth of DE, and so on, the ratio of any term to all the succeeding ones taken together, exceeds a ratio of equality more than the ratio it has to the same number of succeeding terms, be that number ever so great, exceeds it, when each term has to the immediately succeeding one the ratio of two to one.

SCHOLIUM.

SCHOLIUM. In like manner is it shewn, that, if AC be a third part of AB, CD of AC, DE of CD, EF of DE, and so on, the ratio of each term to all the succeeding ones taken together, be their number ever so great, exceeds the ratio of two to one; and, in general, if the ratios AB to AC, AC to CD, CD to DE, DE to EF, &c. be respectively the same with that of A to N, that the ratio of each term to all the succeeding ones, be their number ever so great, exceeds the ratio of A—N to N. This is also evident from the well known method of finding the aggregates of geometrical progressions; and if the ratio of AC to CD be greater than that of AB to AC, the ratio of CD to DE greater than that of AC to CD, and so on, the ratio of any term to all the succeeding ones, be their number ever so great, exceeds the ratio of A—N to N, more, than the ratio it has to the same number of succeeding terms, exceeds it, when each term has to the immediately succeeding one the ratio of A to N.

I NOW proceed to prove, that each of the general geometrical expressions in p. 3. *Antecedental Calculus*, viz.

$$\frac{R}{Q} \cdot A \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \frac{R-2Q}{Q} \cdot N^2 + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot A \frac{R-3Q}{Q} \cdot N^3 + \&c.$$

$$\frac{B \frac{R-Q}{Q}}{\quad}$$

and

$$\frac{R}{Q} \cdot A \frac{R-Q}{Q} \cdot N - \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot A \frac{R-2Q}{Q} \cdot N^2 + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot A \frac{R-3Q}{Q} \cdot N^3 - \&c.$$

$$\frac{B \frac{R-Q}{Q}}{\quad}$$

has to N a ratio nearer to the ratio of $\frac{R}{Q} \cdot A \frac{R-Q}{Q}$ to B than any

given or assigned ratio, or than by any given or assigned magnitude, when A+N and A—N have either to A or B ratios nearer to that of equality than any given, or assigned ratio, or

than by any given, or assigned magnitude, and R and Q are two given magnitudes of the same kind.

PROPOSITION I.

IN this case, the first term in each of these general expressions has to twice the second, the second to thrice the third, the third to four times the fourth, the fourth to five times the fifth, and so on, a ratio greater than any given ratio.

FOR, if this be denied, let C and D be two given homogeneous magnitudes, and let the ratio of C to D be greater.

IN each, the ratio of the first term to twice the second, is that of A to $\frac{R-Q}{Q} \cdot N$, and its inverse $\frac{R-Q}{Q} \cdot N$, or $(N + N \cdot \frac{R-2Q}{Q})$, to A , is the ratio compounded of the ratios of $R-Q$ to Q , and N to A , (For. 1. Theor. 1. *Universal Comparison*). Now, the ratio compounded of this ratio, and that of C to D , is a ratio compounded of the three ratios C to D , $R-Q$ to Q , and N to A . But, since R and Q are given magnitudes, $R-Q$ is a given magnitude, (4. Euc. Data), and the ratio of $R-Q$ to Q a given ratio, (1. Data). Wherefore the ratio compounded of the ratios of C to D and $R-Q$ to Q , is also given, (67. Data). This ratio, however, compounded with that of N to A , is the same with the ratio compounded of C to D , and $\frac{R-Q}{Q} \cdot N$ to A . But since that of A to N is by the hypothesis greater than any given ratio, the ratio compounded of C to D and $R-Q$ to Q , compounded with that of N to A , produces a ratio of less inequality, (Lemma 2.). Consequently, the ratio of A to $\frac{R-Q}{Q} \cdot N$ is greater than any given ratio C to D . Wherefore, the supposition,

fition, that any given ratio C to D is greater than it, is absurd.

AND, since the ratio of the second term to thrice the third, is that of A to $\frac{R-2Q}{Q} \cdot N$, it is proved exactly in the same manner, that this ratio is greater than any given ratio. And precisely in the same way is it demonstrated, that the ratio of the third term to four times the fourth, is greater than any given ratio; and so on.

COR. 1. If $R-Q$ be equal to Q , the ratio compounded of C to D, and $R-Q$ to Q , is the same with that of C to D, (Lemma 3.); and if $R-Q$ be greater or less than Q , the ratio compounded of C to D and $R-Q$ to Q , is accordingly greater or less than that of C to D, (Cor. to Lemma 3.).

COR. 2. The magnitudes, $\frac{2R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-Q}{Q}} N$, $\frac{R}{Q} \cdot \frac{R-Q}{Q} \cdot \frac{A \frac{R-2Q}{Q}}{B \frac{R-2Q}{Q}} N$,

&c. $\frac{2R}{Q} N$, $\frac{R-Q}{Q} N$, $\frac{R-2Q}{Q} N$, &c. are less than any given or assigned magnitude.

COR. 3. The ratio of each term to all the succeeding ones, be their number ever so great, is greater than any given ratio, (Scholium to Lemma 4.).

COR. 4. The magnitudes $A \pm \frac{R-Q}{Q} N$, $A \pm \frac{R-2Q}{Q} N$, &c. have respectively to A ratios nearer to that of equality than any given ratio, or than by any given magnitude.

COR. 5. The magnitude which has to B a ratio, having to the ratio of A to B the ratio of R to Q , has to twice the first term, in each of these general geometrical expressions, a ratio greater than any given ratio.

PROPOSITION II.

THE ratio of each of these two general geometrical expressions to N, is nearer to the ratio of $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-2Q}{Q}}$ to B than any given or assigned ratio.

FOR, since the first term in each has to twice the second a ratio greater than any given or assigned ratio, (Prop. 1.), and the second has to all the succeeding terms, be their number ever so great, a ratio greater than any given ratio, (Cor. 3. Prop. 1.) the ratio of the first term to all the succeeding ones is *a fortiori* greater than any given ratio, being greater than that of A to $\frac{R-Q}{Q} \cdot N$. Wherefore each of these expressions has to the first term a ratio nearer to that of equality than any given or assigned ratio, or than by any given or assigned magnitude, (Cor. 4. Prop. 1.). Consequently the ratios which these expressions have to N, are nearer to the ratio of the first term in each to N, than any given or assigned ratio. But the ratio of the first term in

each to N, is that of $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-2Q}{Q}}$ to B. Therefore, &c. Q.E.D.

OTHERWISE:

IN the first expression, the first term, with twice the second, is much greater than the whole of it, (Cor. 3. Prop. 1.), and consequently has to N a greater ratio than the expression itself has to N, (8. E. 5.). But this ratio exceeds the ratio of the first term to N less than any given or assigned ratio. For, if the ratio

tio of the first term to N be compounded with it, or its inverse, the ratio of N to the first term, be compounded with it, there arises the ratio of $A + \frac{R-Q}{Q} \cdot N$ to A, which (Cor. 4. Prop. 1.) is nearer to a ratio of equality than any given ratio.

IN the second, the excess of the first term above twice the second is less than the whole expression, and consequently has to N a less ratio than the expression itself has to N, (8. E. 5.). But if with it the ratio of N to the first term be compounded, there arises the ratio of $A - \frac{R-Q}{Q} \cdot N$ to A, which (Cor. 4. Prop. 1.) is nearer to a ratio of equality than any given ratio. Q. E. D.

OTHERWISE:

If it be denied, that each expression has to N a ratio nearer to the ratio of its first term to N than any given ratio, let the ratio of two given magnitudes C and D be nearer to it, and let the ratio of B to E, compounded with that of the first term to

N, or with the given ratio $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-2Q}{Q}}$ to B, be equal to the given ratio C to D. But the magnitude, which has to B the ratio compounded of these two ratios, is (For. 1. Theorem 1.

Universal Comparison), $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-2Q}{Q}} + \frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{B \frac{R-2Q}{Q}} \cdot \frac{B-E}{E}$ to B,

which is greater than the ratio of the first term to N, and less than the ratio of the first expression to N, by the supposition, and consequently less than the ratio of the first term with twice the

the second to N. Therefore $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{\frac{B \frac{R-2Q}{Q}}{Q}} \cdot \frac{B-E}{E}$ is less than

$\frac{R}{Q} \cdot \frac{R-Q}{Q} \cdot \frac{A \frac{R-2Q}{Q}}{\frac{B \frac{R-2Q}{Q}}{Q}} \cdot N$. But since the ratio of $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{\frac{B \frac{R-2Q}{Q}}{Q}}$ to E,

being compounded of the first term to N, and of B to E, is the same with the ratio of C to D, E is a given magnitude, (2. Data), and B—E a given magnitude, (4. Data). Wherefore the given

magnitude, $\frac{R}{Q} \cdot \frac{A \frac{R-Q}{Q}}{\frac{B \frac{R-2Q}{Q}}{Q}} \cdot \frac{B-E}{E}$, is less than $\frac{R}{Q} \cdot \frac{R-Q}{Q} \cdot \frac{A \frac{R-2Q}{Q}}{\frac{B \frac{R-2Q}{Q}}{Q}} \cdot N$,

which (Cor. 2. Prop. 1.) is less than any given magnitude, which is absurd.

In like manner is it demonstrated, that the ratio of the second expression to N, is nearer to the ratio of its first term to N than any given ratio. Q. E. D.

SCHOLIUM.

If the same reasoning be applied to the expression,

$\frac{\frac{R}{Q} \cdot A \frac{R-Q}{Q} \cdot N + \frac{R}{Q} \cdot \frac{R-Q}{2Q} \cdot \frac{R-2Q}{3Q} \cdot A \frac{R-3Q}{Q} \cdot N^3 + \&c.}{\frac{B \frac{R-Q}{Q}}{Q}}$, which is half

the difference of the two geometrical expressions that have respectively to B ratios having to the ratios of A+N to B, and A—N to B, the ratio of R to Q, we get the ratio of the first term to twice the second, the same with that of A to $\frac{R-Q}{Q} \cdot \frac{R-2Q}{3Q} \cdot \frac{N^2}{A}$, and the ratio of the second to four times the third,

third the same with that of A to $\frac{R-3Q}{Q} \cdot \frac{R-4Q}{5Q} \cdot \frac{N^2}{A}$, and so on.

THE general expression, (p. 5. *Antecedental Calculus*), gives $\frac{A.N + C.M + M.N}{D}$ for the excess of the magnitude, which has to

B the ratio, that is produced by compounding the ratio of C+N to D with that of A+M to B, above the magnitude, which has to B the ratio compounded of the ratios of A to B and C to D. But it is demonstrated in the same manner as above, that if A+M and C+N have respectively to A and C ratios nearer to that of equality than any given or assigned ratio, or than by any given or assigned magnitude, this expression also has to $\frac{A.N + C.M}{D}$ a ratio nearer to that of equality than any given ra-

tio, or than by any given magnitude. And the demonstration is exactly the same, when any number of ratios are compounded.

IN like manner, if the ratio of C+N to D be decomposed with that of A+M to B, we get the difference between the expression thence arising, and the magnitude which has to B the ratio produced by decomposing the ratio of C to D with that

of A to B, equal to $\frac{CD.M - AD.N}{C.C+N}$. But it is readily demon-

strated, as above, that if A+M and C+N have respectively to A and C ratios nearer to that of equality than any given or assigned ratio, or than by any given or assigned magnitude, this expression also has to $\frac{CD.M - AD.N}{C^2}$ a ratio nearer to that of equality than any given ratio, or than by any given or assigned magnitude.

It is manifest then, that in this calculus no indefinitely small or infinitely little magnitudes are supposed, but only magnitudes less than any that may be given or assigned, and ratios nearer to that of equality than any that may be given or assigned,

ed, and that it is equally geometrical with the method of exhaustions of the ancients, who never supposed lines, surfaces, or solids, to be resolved into indefinitely small or infinitely little elements. The expression *infinitely little magnitude* indeed implies a contradiction. For what has magnitude cannot be infinitely little.

THIS geometrical calculus, though it has no connection with the various modifications of motion, is equally convenient in its application with the method of fluxions, (which is unquestionably a branch of general arithmetical proportion, in which 1 or unit is the common standard of comparison, as well as the consequent of every ratio compounded, or decompounded).

EXAMPLE I.

IN the circle ATB, (Fig. I. Pl. I.) let the diameter AB be represented by D, TE perpendicular to it by Y, and AE by X. Then (13. E. 6.) Y^2 is equal to the rectangle $DX - X^2$. But the antecedental of Y^2 is $2Y\dot{Y}$, and that of $DX - X^2$ is $D\dot{X} - 2X\dot{X}$, (p. 6. *Antecedental Calculus*). Wherefore $D - 2X$ is to $2Y$ as \dot{Y} to \dot{X} , that is, as TE to CE, (p. 9. *Ant. Cal.*). Consequently CE is a third proportional to EO and TE.

EXAMPLE II.

To find the surface of the sphere of which ATBA is a great circle, (Fig. I. Pl. I.).

THE surface of the spherical segment, cut off by the circle, of which TE is the radius, has to the square on any given line B, a ratio compounded of the circumference of said circle to B, and of the antecedental of the curve AT to B, (*Ant. Cal.* p. 9.) But the antecedental of the curve is a fourth proportional to 2YD and

and $\overset{a}{X}$, (*ibidem*). Wherefore, if $2Y \times p$ represent said circumference, the antecedental of the spherical segment is $pD\overset{a}{X}$, of which the antecedent is pDX .

EXAMPLE III.

IF it be required to draw a tangent to the parabola (Fig. 2. Pl. 1.) ATG at the point T; let the latus rectum be represented by L. Then L.X is equal to Y^2 , and $L.\overset{a}{X}$ to $2Y\overset{a}{Y}$. Wherefore L is to $2Y$ ($2TE$) as $\overset{a}{Y}$ to $\overset{a}{X}$, that is, (*Ant. Cal.* p. 9.) as TE to CE, which is consequently equal to twice AE.

EXAMPLE IV.

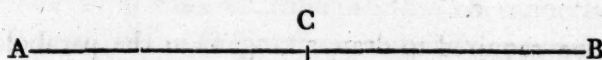
IN finding the area of the parabola, since $\overset{a}{X}$ is equal to $\frac{2Y\overset{a}{Y}}{L}$, we get the antecedental of the area, or $Y\overset{a}{X}$, equal to $\frac{2Y^2\overset{a}{Y}}{L}$, the antecedent of which is $\frac{2Y^3}{3L}$, or its equal $\frac{2}{3} \times XY$.

OTHERWISE:

THE ratios of the antecedentials of the area AET, and the rectangle under AE, and any given line B to the square on B, are $Y\overset{a}{X}$ and $B\overset{a}{X}$ to B^2 . But $Y\overset{a}{X}$ is equal to $\frac{2Y^2\overset{a}{Y}}{L}$, the antecedent of which is $\frac{2Y^3}{3L}$, or its equal $\frac{2}{3} \times XY$; and the antecedent of $B\overset{a}{X}$ is BX. Wherefore the area of the parabola is two thirds of the rectangle AE, ET.

EXAMPLE V.

So to divide a straight line AB, that the rectangle under the two parts AC, CB shall be the greatest possible.



Let AB be represented by A, AC by X, and consequently CB by A—X. Then the rectangle AC, CB is equal to $AX - X^2$, the antecedental of which is $A\dot{X} - 2X\dot{X}$, which, when supposed equivalent to nothing, (according to *Ant. Cal.* p. 7.) gives A equal to 2X, or AC equal to CB.

To multiply examples would be useless. I will take an opportunity, as soon as I conveniently can, of applying this calculus to several physical problems of importance, and particularly some respecting the resistance of fluids; and will shew, that as it furnishes a much greater variety of ways for expressing antecedentials than the fluxionary calculus does for fluxions, so it will open new and extensive rules for finding antecedents, as yet altogether unknown in the inverse method of fluxions.

ALTHOUGH the notation be in reality of no importance, I prefer \dot{X} , \dot{Y} , &c. to \dot{X} , \dot{Y} , &c. as more indicative of the origin of this mode of reasoning, which was derived from an examination of the antecedents of ratios in general geometrical comparison.

IV. OB-

IV. OBSERVATIONS on the TRIGONOMETRICAL TABLES of the
BRAHMINS. By JOHN PLAYFAIR, F. R. S. EDIN. and
Professor of Mathematics in the University of Edinburgh.

[Read April 6. 1795.]

1. **I**N the second volume of the *Asiatic Researches*, an extract is given from the *Surya Siddhanta*, the ancient book which has been long, though obscurely, pointed out as the source of the astronomical knowledge of the Brahmins. The *Surya Siddhanta* is in the Sanscrit language: It is one of the Sastras, or inspired writings of the Hindoos, and is called the Jyotish, or Astronomical, Sastra. It professes, as we learn from Mr DAVIS, the ingenious translator, to be a revelation from heaven, communicated to MEYA, a man of great sanctity, about four millions of years ago, toward the close of the Satya Jug, or of the Golden Age of the Indian mythologists; a period at which man is said to have been incomparably better than he is at present; when his stature exceeded twenty-one cubits, and his life extended to ten thousand years.

INTERWOVEN, however, with all these extravagant fictions, this singular book contains a very sober and rational system of astronomical calculation; and even the principles and rules of trigonometry, a science of all others the most remote from fable, and the least susceptible of poetical decoration. It is on the con-

struction of the tables contained in this trigonometry, that I now beg leave to offer a few remarks.

2. It is necessary to begin with observing, that the circumference of the circle is here divided into 360 equal parts, each of which is again subdivided into 60, and so on. The same division was followed by the Greek mathematicians; and this coincidence is the more to be remarked, that it relates to a matter of arbitrary arrangement, and one by no means necessarily connected with the properties of the circle. There are indeed some very obvious properties of that curve, that make it, though not necessary, at least convenient, that the number of parts, into which the circumference is divided, should be a number divisible both by 3 and by 4, that is, that it should be a multiple of 12; but nothing more precise can be determined from the nature of the curve itself. The agreement of two nations, therefore, in dividing the circumference of the circle precisely in the same manner, as it cannot well be attributed to chance, must be supposed to result from some communication having taken place between them, if it were not that another very probable cause may be assigned for it. In Greece, and no doubt in every other country, the division of the circle, into equal parts, is of a much older date than the origin of trigonometry, and must be as ancient as the first circular instruments used for measuring angles in the heavens. The inventors of those instruments naturally sought to make the divisions on them correspond to the space which the sun described daily in the ecliptic; and they could easily discover, without any very precise knowledge of the length of the solar year, that this might be nearly effected by making each of them the 360th part of the whole circumference. Accordingly the famous circle of OSMANDIAS, in Egypt, described by HERODOTUS, was divided into 360 equal parts.

THIS

THIS principle may therefore have guided the astronomers, both of the East and of the West, to the same division of the circle, without any intercourse having taken place between them. It has certainly directed the Chinese in their division, though it has led them to adopt one different from the Hindoo and Egyptian astronomers. They divide the circle into 365 parts and $\frac{1}{4}$, which can have no other origin than the sun's annual motion: and some such division as this, may perhaps have been the first that was employed by other nations, who changed it however to the number 360, which nearly answered the same purpose, and had besides the great advantage of being divisible into many aliquot parts. The Chinese, again, with whom the sciences became stationary almost from their birth, have never attempted to improve on the method that first occurred to them.

3. THE next thing to be mentioned, is also a matter of arbitrary arrangement, but one in which the Brahmins follow a method peculiar to themselves. They express the radius of the circle in parts of the circumference, and suppose it equal to 3438 minutes, or 60ths of a degree. In this they are quite singular. PROLEMY, and the Greek mathematicians, after dividing the circumference, as we have already described, supposed the radius to be divided into 60 equal parts, without seeking to ascertain, in this division, any thing of the relation of the diameter to the circumference: and thus, throughout the whole of their tables, the chords are expressed in sexagesimals of the radius, and the arches in sexagesimals of the circumference. They had therefore two measures, and two units; one for the circumference, and another for the diameter. The Hindoo mathematicians, again, have but one measure and one unit for both, viz. a minute of a degree, or one of those parts whereof the circumference contains 21600. From this identity of measures, they derive no inconsiderable advantage in many calculations, though it must be confessed, that the measuring of a straight line, the radius,

radius, or diameter of a circle, by parts of a curve line, namely, the circumference, is a refinement not at all obvious, and has probably been suggested to them by some very particular view, which they have taken, of the nature and properties of the circle. As to the accuracy of the measure here assigned to the radius, viz. 3438 of the parts of which the circumference contains 21600, it is as great as can be attained, without taking in smaller divisions than minutes, or 60ths of a degree. It is true to the nearest minute, and this is all the exactness aimed at in these trigonometrical tables. It must not however be supposed, that the author of them meant to assert, that the circumference is to the radius, either accurately or even very nearly, as 21600 to 3438. I have shewn, in another place*, from the Institutes of AKBAR, that the Brahmins knew the ratio of the diameter to the circumference to great exactness, and supposed it to be that of 1 to 3.1416, which is much nearer than the preceding. Calculating, as we may suppose, by this or some other proportion, not less exact, the authors of the tables found, that the radius contained in truth $3437^{\circ}.44''.48'''$, &c.; and as the fraction of a minute is here more than a half, they took, as their constant custom is, the integer next above, and called the radius 3438 minutes. The method by which they came to such an accurate knowledge of the ratio of the diameter to the circumference, may have been founded on the same theorems which were subservient to the construction of their trigonometrical tables†.

4. THESE tables are two, the one of sines, and the other of versed sines. The sine of an arch they call *cramajya* or *jyapinda*, and the versed sine *utcramajya*. They also make use of the cosine or *bbujajya*. These terms seem all to be derived from the word *jya*, which signifies the chord of an arch, from which the
name

* Trans. R. S. Edin. vol. II. p. 185. Phys. Cl.

† See Note, § 6.

name of the radius, or sine of 90° , viz. *trijya*, is also taken. This regularity in their trigonometrical language, is a circumstance not unworthy of remark. But what is of more consequence to be observed, is, that the use of sines, as it was unknown to the Greeks, who calculated by help of the chords, forms a striking difference between the Indian trigonometry and theirs. The use of the sine, instead of the chord, is an improvement which our modern trigonometry owes, as we have hitherto been taught to believe, to the Arabs; and it is certainly one of the acquisitions which the mathematical sciences made, when, on their expulsion from Europe, they took refuge in the East. But whether the Arabs are the authors of this invention, or whether they themselves received it, as they did the numerical characters, from India, is a question, which a more perfect knowledge of Hindoo literature will probably enable us to resolve.

No mention is made in this trigonometry, of tangents or secants; a circumstance not wonderful, when we consider that the use of these was introduced in Europe no longer ago than the middle of the sixteenth century. It is, on the other hand, not a little singular, that we should find a table of versed sines in the *Surya Siddhanta*; for neither the Greek nor the Arabian mathematicians, had any such, nor had we, in modern Europe, till after the time of PETISCUS, who wrote about the end of the century just mentioned.

5. NEXT, as to the extent and accuracy of these tables. The first of them exhibits the sines to every twenty-fourth part of the quadrant, that is, the sine of $3^\circ. 45'$, and of all the multiples of that arch, viz. $7^\circ. 30'$, $11^\circ. 15'$, &c. up to 90° . The table of versed sines does the same. In each, the sine, or versed sine, is expressed in minutes of the circumference, but without any fractions of a minute, either decimal or sexagesimal; and, agreeably to the observation already made, when the fraction that ought

to have been set down is greater than $\frac{1}{2}$, the integer next greater is placed in the table. Thus the sine $3^{\circ} 45'$ being, when accurately expressed in their way, $224'.49''$, is put down $225'$; and so of the rest. The numbers, therefore, in these tables, are only so far exact as never to differ more than half a minute from the truth, and this very limited degree of accuracy gives no doubt to their trigonometry the appearance of an infant science: But when, on the other hand, we consider the principles and rules of their calculations, rather than the numbers actually calculated, we find the marks of a science in full vigour and maturity: and we will acknowledge, that the Hindoo mathematicians did not satisfy themselves with the degree of accuracy above mentioned, from any incapacity of attaining to greater exactness.

THEIR rules for constructing their tables of sines, may be reduced to two, *viz.* the one for finding the sine of the least arch in the table, that of $3^{\circ} 45'$, and the other for finding the sines of the multiples of that arch, its triple, quadruple, &c. Both of these Mr DAVIS has translated, judging very rightly, that it was impossible to give two more curious specimens of the geometrical knowledge of the Hindoo philosophers: the first is extracted from a commentary on the Surya Siddhanta; the other from the Surya Siddhanta itself.

6. WITH respect to the first, the method proceeds by the continual bisection of the arch of 30° , and correspondent extractions of the square root, to find the sine and co-sine of the half, the fourth part, the eighth part, and so on, of that arch. The rule, when the sine of an arch is given, to find that of half the arch, is precisely the same with our own: "The sine of an arch being given, find the co-sine, and thence the versed sine, of the same arch: then multiply half the radius into the versed sine, and the square root of the product is the sine of half the given arch." Now, as the sine of 30° , was well known to those mathematicians to be half the radius, it was of consequence given: thence,
by

by the rule just laid down, was found the sine of 15° , then of $7^\circ. 30'$, and lastly of $3^\circ. 45'$, which is the sine required. Thus the sine of $3^\circ. 45'$ would be found equal to $224'. 44''$, as above observed, and, the sine of $7^\circ. 30'$, equal to $448'. 39''$, and, taking the nearest integers, the first was made equal to 225, and the second to 449*.

7. WHEN, by the bisections that have just been described, the sine of $3^\circ. 45'$, or of 225', was found equal to 225', the rest of the table was constructed by a rule, that, for its simplicity and elegance, as well as for some other reasons, is entitled to particular attention. It is as follows: "Divide the first jyapinda, 225' by 225; the quotient 1, deducted from the dividend, leaves 224', which added to the first jyapinda, or sine, gives the second, or the sine of $7^\circ. 30'$, equal to 449'. Divide the second jyapinda, which is thus found, by 225, and deduct 2, the nearest integer to the quotient, from the former remainder 224', and this new remainder 222', added to the second jyapinda, will give the third jyapinda equal to 671'. Divide this last by 225, and subtract 3, the nearest integer to the quotient, from the former remainder 222', and there will be left 219',
M which,

* By such continual bisections, the Hindoo mathematicians, like those of Europe before the invention of infinite series, may have approximated to the ratio of the diameter to the circumference, and found it to be nearly that of 1 to 3.1416 as above observed. A much less degree of geometrical knowledge than they possessed, would inform them, that small arches are nearly equal to their sines, and that the smaller they are, the nearer is this equality to the truth. If, therefore, they assumed the radius equal to 1, or any number at pleasure, after carrying the bisection of the arch of 30, two steps farther than in the above construction, they would find the sine of the 384th part of the circle, which, therefore, multiplied by 384, would nearly be equal to the circumference itself, and would actually give the proportion of 1 to 3.14159, as somewhat greater than that of the diameter to the circumference. By carrying the bisections farther, they might verify this calculation, or estimate the degree of its exactness, and might assume the ratio of 1 to 3.1416 as more simple than that just mentioned, and sufficiently near to the truth.

which, added to the third jyapinda, gives the fourth; and so on unto the twenty-fourth or last."

It is not immediately obvious on what geometrical principle this rule is founded, but a slight change in the enunciation will remove the difficulty. The remainder, it must be observed, from which the quotient is always directed to be taken away, is the difference between the two fines last computed; and hence the rule may be expressed more generally: Divide any fine by 225, and subtract the quotient, or the integer nearest the quotient, from the difference between that fine and the fine next less; the remainder is the difference between the same fine and the fine next greater; and therefore if it be added to the former, will give the latter. If then, (fig. 3. Pl. I.), GA, GC, GE, be three contiguous arches in the table, of which the differences AC, CE, of consequence are equal, and of which the fines are AB, CD, and EF, the rule, as last stated, gives us $CD - AB - \frac{CD}{225}$, for the difference between CD and EF, and therefore $EF = CD + CD - AB - \frac{CD}{225} = 2CD - \frac{CD}{225} - AB$, and also $EF + AB = CD \left(2 - \frac{1}{225} \right) = CD \left(\frac{449}{225} \right)$. But 225 is the fine of the arch $3^\circ. 45'$, and 449 of twice that arch, as already shewn; and, therefore, according to this rule, if there be three arches, of which the common difference is $3^\circ. 45'$, the fine of the mean arch will always have to the sum of the fines of the extreme arches, a given ratio, that namely, which the fine of $3^\circ. 45'$ has to the fine of twice $3^\circ. 45'$, or of $7^\circ. 30'$; now, this is a true proposition; and therefore we are in possession of the principle on which the Hindoo canon is constructed.

8. THE geometrical theorem, which is thus shewn to be the foundation of the trigonometry of Hindostan, may also be more generally enunciated. "If there be three arches in arithmetical progression, the fine of the middle arch is to the sum of the fines of

of the two extreme arches, as the sine of the difference of the arches to the sine of twice that difference." This theorem is well known in Europe; it is justly reckoned a very remarkable property of the circle; and it serves to shew, that the numbers in a table of sines constitute a series, in which every term is formed exactly in the same way, from the two preceding terms, *viz.* by multiplying the last by a certain, constant number, and subtracting the last but one from the product.

9. Now, it is worth remarking, that this property of the table of sines, which has been so long known in the East, was not observed by the mathematicians of Europe till about two hundred years ago. The theorem, indeed, concerning the circle, from which it is deduced, under one shape or another, has been known to them from an early period, and may be traced up to the writings of EUCLID, where a proposition nearly related to it forms the 97th of the *Data*: "If a straight line be drawn within a circle given in magnitude, cutting off a segment containing a given angle, and if the angle in the segment be bisected by a straight line produced till it meet the circumference; the straight lines, which contain the given angle, shall both of them together have a given ratio to the straight line which bisects the angle." This is not precisely the same with the theorem which has been shewn to be the foundation of the Hindoo rule, but differs from it only by affirming a certain relation to hold among the chords of arches, which the other affirms to hold of their sines. It is given by EUCLID as useful for the construction of geometrical problems; and trigonometry being then unknown, he probably did not think of any other application of it. But what may seem extraordinary is, that when, about 400 years afterwards, PTOLEMY, the astronomer, constructed a set of trigonometrical tables, he never considered EUCLID's theorem, though he was probably not ignorant of it, as having any connection with the matter he had in hand. He,

therefore, founded his calculations on another proposition, containing a property of quadrilateral figures inscribed in a circle, which he seems to have investigated on purpose, and which is still distinguished by his name. This proposition comprehends in fact EUCLID's, and of course the Hindoo theorem, as a particular case; and though this case would have been the most useful to PROLEMY, of all others, it appears to have escaped his observation; on which account he did not perceive that every number in his tables might be calculated from the two preceding numbers, by an operation extremely simple, and every where the same; and therefore his method of constructing them is infinitely more operose and complicated than it needed to have been.

Not only did this escape PROLEMY, but it remained unnoticed by the mathematicians, both Europeans and Arabians, who came after him, though they applied the force of their minds to nothing more than to trigonometry, and actually enriched that science by a great number of valuable discoveries. They continued to construct their tables by the same methods which PROLEMY had employed, till about the end of the sixteenth century, when the theorem in question, or that on which the Hindoo rule is founded, was discovered by VIETA. We are however ignorant by what train of reasoning that excellent geometer discovered it; for though it is published in his *Treatise on Angular Sections*, it appears there not with his own demonstration, but with one given by an ingenious mathematician of our own country, ALEXANDER ANDERSON of Aberdeen. It was then regarded as a theorem entirely new, and I know not that any of the geometers of that age remarked its affinity to the propositions of EUCLID and PROLEMY. It was soon after applied in Europe, as it had been so many ages before in Hindostan, and quickly gave to the construction of the trigonometrical canon all the simplicity which it seems capable of attaining. From all this, I think it might fairly be concluded, even if we had

had no knowledge of the antiquity of the Surya Siddhanta, that the trigonometry contained in it is not borrowed from Greece or Arabia, as its fundamental rule was unknown to the geometers of both those countries, and is greatly preferable to that which they employed.

10. CONSIDERABLE light may perhaps hereafter be thrown on this argument, if it be found that the Surya Siddhanta contains a demonstration of this rule. It does not appear, however, from the fragment we are in possession of, that any explanation of the rule is given, either in that work, or in the commentary. Indeed I am not certain that the Surya Siddhanta contains any thing but rules and maxims, or that the author of it condescends to give any demonstrations of the propositions which he enunciates. He may have felt himself relieved from the necessity of doing so, by his claim to inspiration; and as he probably valued himself more on the character of a prophet, than of a geometer, he may rather have inclined to exercise the faith, than the reason, of his disciples.

HOWEVER that be, by the rule above explained, the Brahmans have computed a set of tables, limited indeed in their accuracy, but extremely simple and compendious. The rule is easily remembered by one who has been accustomed to numerical calculation, and is such, that, by help of it, he may at any time compose for himself a complete set of trigonometrical tables, in a few hours, without the assistance of any book whatever. For the purpose of rendering it thus simple, the contrivance of measuring the radius, and all the sines, in parts of the circumference, seems to have been adopted: if we follow any other method, the rule, though it remain the same in reality, will assume a form much less easy to be retained in the memory*. It has the appearance, like many other things in the science

* This seems to me the most probable reason that can be assigned for the measuring of the radius, and the other straight lines in the circle, in parts of the circumference.

science of those eastern nations, of being drawn up by one who was more deeply versed in the subject than may be at first imagined, and who knew much more than he thought it necessary to communicate. It is probably a compendium, formed by some ancient adept in geometry, for the use of others who were merely practical calculators.

11. If we were not already acquainted with the high antiquity of the astronomy of Indostan, nothing could appear more singular, than to find a system of trigonometry, so perfect in its principles, in a book so ancient as the *Surya Siddhanta*. The antiquity of that book, the oldest of the *Sastras*, can scarce be accounted less than 2000 years before our æra, even if we follow the very moderate system of Indian chronology laid down by Sir WILLIAM JONES *. Now, if we suppose its antiquity to be no higher than this, though it bears in itself internal marks of an age still more remote†, yet it will sufficiently excite our wonder, to find it contain the principles of a science, of which the first rudiments

ference. It is remarkable that the Hindoos should have been thus led, at so early a period, to put in practice a method, the same in the most material point, with one which has been but lately suggested in Europe as an important improvement in trigonometrical calculation. In the *Phil. Trans.* for 1783, Dr HUTTON of Woolwich proposed to divide the circumference, not into degrees, as is usually done, but into decimals of the radius; and he has pointed out how the present trigonometrical tables might be accommodated to this new division, with the least possible labour, in a paper which displays that intimate acquaintance with the resources, both of the numerical and algebraic calculus, for which he is so much distinguished. His plan is, in one respect, the same with the Hindoo method, for it uses the same unit to express both the circumference and the diameter; in another respect it differs from it, *viz.* in making the radius the unit, while the other assumes for an unit the 360th part of the circumference. Dr HUTTON's plan has never been executed, though it certainly would be of advantage to have, besides the ordinary trigonometrical tables, others constructed according to that plan.

* Asiatic Researches, vol. II. p. 111, &c.

† The obliquity of the ecliptic is stated at 24° in the *Surya Siddhanta*, as in all the other astronomical tables of the Hindoos which we are yet acquainted with.

(Trans.

rudiments are not older in Greece than 130 years before our æra. The bare existence of trigonometrical tables, though they belong undoubtedly to a very elementary branch of science, yet argues a state of greater advancement in the mathematics than may at first be imagined, and necessarily supposes the application of geometrical reasoning to some of the more difficult problems of astronomy and geography.

As long as the surveying of land, and the ordinary mensuration of surfaces and solids, are the only practical arts to which the geometer applies his speculations, he will naturally content himself with constructing his figures and plans by means of a scale, and an instrument for measuring angles, as by doing so he may attain to all the accuracy he can desire. But when, in the figures that are to be thus delineated, the sides happen to be extremely unequal, and some of the angles very acute, or very obtuse, graphical operations become inaccurate, and a very small error in the measuring of one thing produces an enormous error in the estimation of some other. Lines, therefore, that extend over a great tract of the earth's surface, and much more those that extend to the heavens, cannot be compared with the smaller lines, which we have an opportunity of measuring, by the bare construction

(Trans. R. S. Edin. vol. II. p. 164.) Mr DAVIS concludes from this, (*Asiatic Researches*, vol. II. p. 238), that if the obliquity diminish, at the rate of $50''$ in a hundred years, the Surya Siddhanta is at present about 3840 years old, which goes back nearly 2000 years before the Christian æra. But the diminution of the obliquity of the ecliptic, is supposed considerably too rapid in this calculation. According to MAYER it is $46''$ in a century; and according to De la GRANGE, (*Mem. Berlin* 1782), at a medium no more than $30''$. This last is most to be depended on, as it proceeds on an accurate inquiry into the law of the secular variation of the obliquity, that variation being by no means uniform. Let us however take the mean, *viz.* $38''$, and the obliquity at the beginning of the present century having been $23^{\circ} 28' 41''$, we shall have 5000 years for the age of the Surya Siddhanta, reckoned from that date, or about 3300 years before CHRIST, which is near the æra of the Caly Yug.

struction of triangles and parallelograms ; and when ever such comparifons are to be made, fome other method muft be fought for. It was precifely in fuch circumftances, that the inventive genius of HIPPARCHUS fuggested the application of arithmetic to afcertain thofe ratios among the fides and angles of figures, which pure geometry afforded no method of expreffing. This union of geometry and arithmetic did not happen, however, till each of thefe fciences feparately had made great progrefs ; for before the days of HIPPARCHUS, EUCLID, ARCHIMEDES, and APPOLONIUS, had all flourifhed in fucceffion, and had produced thofe immortal works, of which the luftre has not been obfcured by the higheft improvements of later ages. In the progrefs of fcience, therefore, the invention of trigonometry is to be confidered as a ftep of great importance, and of confiderable difficulty. It is an application of arithmetic to geometry, with which we are now too familiar, to perceive all the merit of the inventor ; but a little reflection will convince us, that he, who firft formed the idea of exhibiting, in arithmetical tables, the ratios of the fides and angles of all poffible triangles, and contrived the means of conftructing fuch tables, muft have been a man of profound thought, and of extenfive knowledge. However ancient, therefore, any book may be, in which we meet with a fystem of trigonometry, we may be affured, that it was not written in the infancy of fcience.

12. As we cannot therefore fuppofe the art of trigonometrical calculation to have been introduced till after a long preparation of other acquifitions, both geometrical and aftronomical, we muft reckon far back from the date of the Surya Siddhanta, before we come to the origin of the mathematical fciences in India. In Greece, the conftellations were firft reprefented on the fphere, if we take a medium between the chronology of NEWTON, and that which is now generally

nerally received, about 1140 years before the Christian æra * ; and HIPPARCHUS invented trigonometry 130 years before the same æra. Even among the Greeks, therefore, an interval, of at least 1000 years, elapsed from the first observations in astronomy, to the invention of trigonometry ; and we have surely no reason to suppose, that the progress of knowledge has been more rapid in other countries.

A THOUSAND years therefore must be added to the age of the Surya Siddhanta, which we suppose here to be 2000 before CHRIST, in order that we may reach the origin of the sciences in Hindostan, and this brings us very nearly to the celebrated æra of the Caly Yug, to which M. BAILLY has already referred the construction of the astronomical tables of that country. And here, I cannot help observing, in justice to an author, of whose talents and genius the world has been so unseasonably and so cruelly deprived, that his opinions, with respect to this æra, appear to have been often misunderstood. It certainly was not his intention to assert, that the Caly Yug was a *real* æra, considered with respect to the mythology of India, or even that at so remote a period the religion of Brahma had an existence. The religious and civil institutions of Hindostan, as they now exist, may be all posterior to this date, and their antiquity is probably to be determined from principles that are not the objects of astronomical discussion. All, I think, therefore, that M. BAILLY meant to affirm, and certainly all that is necessary to his system, is, that the Caly Yug, or the year 3102 before our æra, marks a point in the duration of the world, before which

N

the

* The sphere of CHIRON and MUSÆUS was constructed, according to NEWTON, about the year 936 before CHRIST, (NEWTON's Chron. chap. i. § 30). According to the system generally received, the ancient sphere, described by EUDOXUS, was constructed about 1350 years before CHRIST, (Dr PLAYFAIR's Chronology, p. 37). The medium is 1143.

the foundations of astronomy were laid in the East, and those observations made, from which the tables of the Brahmins have been composed.

ON this, however, and on many more of the particulars of the history of those remote ages, great additional light will undoubtedly be thrown, by the complete translation of the Surya Siddhanta. From the specimen which Mr DAVIS has given, we can neither doubt of the importance of such a work, nor of his abilities to execute it; and we trust, that, to the zeal and liberality of our brethren of the Asiatic Society, the learned world will soon be indebted for the possession of this inestimable treasure.

V. *Some GEOMETRICAL PORISMS, with EXAMPLES of their APPLICATION to the SOLUTION of PROBLEMS. By Mr WILLIAM WALLACE, Assistant-Teacher of the Mathematics in the Academy of Perib. Communicated by Mr PLAYFAIR.*

[Read March 7. 1796.]

THE nature of those mathematical propositions, which were called Porisms by the ancient geometers, is now no longer a matter of uncertainty. The relation which they bear to other mathematical truths, the way in which they may at first have been observed, the kind of analysis to be employed in their investigation, their application to the solution of problems, have all been considered by some eminent mathematicians of the present age.

THESE propositions appear to have been held in high estimation by the mathematicians of antiquity, because of their great use in the analysis of difficult problems, as we learn from the writings of PAPPUS of Alexandria: And some specimens, which late inquirers into this subject have given us, of their application to the solution of problems, seem to justify his very high character of them.

THE following paper contains some porisms intimately connected with each other, and which seem capable of being applied to the solution of a number of geometrical problems. Ex-

amples of their application are added, some of which are problems that have been long known, and others are new; but the constructions of the former, it is believed, differ from any hitherto published. Although there are several of these examples, in appearance, little related to each other, yet their solutions are effected by the same general principle, which is also the foundation of all the porisms.

PROP. I. PORISM, Fig. 4, 5. PL. I.

LET AB, AC, be two straight lines given by position, let B, C, be given points in these lines, a point H may be found, such, that any circle whatsoever passing through A, the intersection of the given lines, and H the point which may be found, shall cut off from the given lines segments BD, CE, adjacent to the given points, and having to each other the given ratio of α to β .

SUPPOSE the porism to be true, and that the point H is found. If a circle be described through H, A, and B one of the given points, it must also pass through C the other given point, that the proposition may be universally true. Therefore H is in the circumference of a given circle. Join BH, CH, DH, EH. The angle DHE is equal to DAE, that is, to BHC, (fig. 4.) or DHE is the supplement of DAE, (fig. 5.) and therefore equal to BHC; hence BHD is equal to CHE, but BDH is equal to CEH, therefore the triangles BDH, CEH, are equiangular, and BH is to HC as BD to CE, that is by hypothesis in the given ratio of α to β ; therefore if BC be joined, the triangle BHC is given in species, and BC being given, BH and HC are given; therefore the point H is given, which was to be found.

IF the segments BD, CE, cut off from the given lines, lie in the same direction with respect to AB, AC, (fig. 4.) the point H will

will be in the same segment of the circle with the angle BAC; but if BD, CE, lie in contrary directions to AB, AC, (fig. 5.) then H will be in that segment of the circle upon which BAC stands.

THE point H will be found by the following construction: Describe a circle through the points A, B, C. Join BC, which divide at G, so that BG may be to GC in the given ratio of BD to CE, that is of α to β , and if the segments to be cut off are to lie in the same direction with AB, AC, find F the vertex of the segment upon which the angle BAC stands, (fig. 4.); but if BD, CE are to lie in opposite directions, (fig. 5.) find F the vertex of the segment BAC, and in either case join FG, which produce to meet the circle in H the point to be found; that is, if any circle be described through H and A to meet the given lines in D and E, BD is to CE as α to β . Join HB, HC, HD, HE. The triangles BDH, CEH are similar, for the angle BDH is equal to CEH, and because the angle BHC is equal to DHE, therefore BHD is equal to CHE; hence BD is to CE as BH to HC, that is, (because HG bisects the angle BHC), as BG to GC, or as α to β .

It is evident that the point H may be also found, by taking any segments BD, CE, in the given ratio of α to β , and describing a circle through the points D, A, E, to meet the circle BAFC in H the point required. If the given lines be parallel, and the points B, C, also the ratio of BD to CE, (fig. 6.) given as before, the indeterminate circle will be changed into a straight line passing through a given point H, which will be without the given lines, or between them, according as BD, CE, are to lie in the same, or in contrary, directions with AB, AC.

PROP. II.

PROP. II. PORISM, Fig. 7. PL I.

LET AF , AG be two straight lines given by position, a point H may be found, such, that any circle whatsoever described through it, and A the intersection of the given lines, to meet them in D and E , shall cut off from them segments AD , AE , whose sum shall be a given line M .

SUPPOSE the porism to be true, and that the point is found, and circle described as above, let given points B , C be so taken, that BA and AC may be together equal to DA and AE , that is, by hypothesis to the given line M , then BD will be equal to CE . If a circle be described through the given points A , B , C , by hypothesis it will meet the circle passing through A , D , E , in H the point which may be found. Join BH , CH , DH , EH . The angle BHC is equal to DHE , each being the supplement of BAC , therefore BHD is equal to CHE ; now, HDB is equal to HEC , and BD is equal to CE , therefore the triangle HBD is equal to HCE , and BH is equal to CH , also DH to EH ; hence the angle BAH is equal to CAH , and H is in a straight line bisecting the angle FAG , but it is also in the given circle BAC ; therefore the point H is given, as was required.

HENCE this construction: Take B and C two given points, so that BA and AC may be together equal to M , and through A , B , C describe a circle. Draw AK bisecting the given angle FAG , and meeting the circle ABC in H the point required, that is, if any circle be described through H and A , to meet the given lines in D and E , the sum of DA and AE shall be equal to the sum of BA and AC , that is, by construction to the given line M . The synthetical demonstration follows readily from the preceding analysis.

PROP. III.

PROP. III. PORISM, Fig. 8. Pl. II.

LET AF , AG be two straight lines given by position, a point H may be found, such, that if any circle be described through it, and A the intersection of the given lines, to meet them in D and E , the difference between AD and AE shall be equal to a given line N .

THE analysis of this proposition will differ in nothing material from the last, and the point required may be found thus: Take B and C , two given points, so that the difference between BA and AC may be equal to N . Through the points A , B , C , describe a circle. Draw AK bisecting the angle contained by FA one of the given lines, and AL the other line produced at their intersection, and AK will meet the circle ABC in H the point which may be found; that is, if any circle be described through H and A , to meet the given lines in D , E , the difference between AD and AE is equal to N the given line.

JOIN AH , BH , CH , DH . The triangles HCE , HBD are equal to one another in every respect, for if BC be joined, the angle HBC is equal to HAL , that is, by construction to HAB , therefore HB is equal to HC ; in the same way it appears that HD is equal to HE ; now, the angle DHE is, equal to DAE , that is to BHC , therefore BHD is equal to CHE , hence BD is equal to CE , and the difference between DA and AE is the same with the difference between BA , AC , which by construction is equal to the given line M .

THESE two last propositions may be considered as particular cases of the following proposition.

PROP. IV.

PROP. IV. PORISM, Fig. 4, 5. Pl. I.

Two straight lines AB, AC being given by position, and two lines P, Q being given in magnitude, a point H may be found, (fig. 5.) such, that any circle described through it and A the intersection of the given lines, to meet them in D, E , shall cut off from them segments AD, AE , so that $P \times AD + Q \times AE$, shall be equal to a given space. Also, the same things being supposed, a point H may be found, (fig. 4.) so that $P \times AD - Q \times AE$, shall be equal to a given space.

LET given points B, C , be taken in either case agreeing with the hypothesis of the proposition, or so that $P \times AB + Q \times AC$, (fig. 5.) may be equal to $P \times AD + Q \times AE$, and so that $P \times AB - Q \times AC$ may be equal to $P \times AD - Q \times AE$, (fig. 4.) then, in both cases, $P \times BD$ will be equal to $Q \times CE$; therefore BD is to CE as Q to P , that is, in a given ratio, and the points B, C being given, the point H may be found, (Prop. 1.).

CONSTRUCTION. Let given points B, C be taken as above directed, and if $P \times AD + Q \times AE$ is to be a given space, (fig. 5.) find a point H , (Prop. 1.) so that any circle described through A and H may meet the given lines in D, E , so that BD, CE may lie in contrary directions to AB, AC , and have to each other the given ratio of Q to P , then $P \times BD$ will be equal to $Q \times CE$, and adding the common space $P \times AB + Q \times AE$ to each, we get $P \times AD + Q \times AE$, equal to $P \times AB + Q \times AC$, that is, to the given space, as was required.

BUT if $P \times AD - Q \times AE$ is to be a given space, (fig. 4.) find H , (Prop. 1.) so that any circle passing through H, A may cut off segments BD, CE , in the given ratio of Q to P , and lying towards the same parts with AB, AC , then $P \times BD$ is equal to $Q \times CE$,

$Q \times CE$, and $P \times AD - Q \times AE$, will be equal to $P \times AB - Q \times AC$, that is, by construction to the given space.

LEMMA, Fig. 9. Pl. II.

If circles be described through A and C any two angles of a triangle ABC, to meet each other at D a point in AC, and the remaining lines AB, BC, in E and F; their other intersection H, the remaining angle B, and the points E, F, are in the circumference of a circle.

JOIN DH, EH, FH. The angle AEH is equal to ADH or CFH, that is, BEH is equal to BFH, hence the points H, B, D, F are in a circle. Q. E. D.

PROP. V. PORISM, Fig. 10. Pl. II.

LET AB, AC, BC be three straight lines given by position, a point H may be found, such, that if any circle be described through H, and B the intersection of any two of the given lines, to meet them in D and F, and if DF be joined meeting the remaining line at E. The line DF shall be divided at E, into segments having to each other a given ratio.

SUPPOSE that the point H is found. Join HA, HB, HC; join also HD, HE, HF. Since, by hypothesis, a circle may pass through the point which is to be found, the intersection of any two of the given lines, and the points where DF meets these lines, therefore the points H, A, D, E are in a circle, and the angle HEF is equal to HAD or HAB; now the points H, B, D, F are supposed to be in a circle; since therefore in the triangle ABC, circles pass through two of its angles A, B, and meet each other at D, a point in AB, (Lemma.) the points H, C, E, F are also

also in a circle; therefore the angle HCF is equal to HEF, that is, (as has been shewn), to HAB; hence the point H, which may be found, is in a circle passing through the points A, B, C, whatever be the given ratio of DE to EF. Let this circle be described.

BECAUSE the points H, A, D, E are in a circle, the angle HAC is equal to HDE, and because H, C, E, F are in a circle, the angle HFE is equal to HCA; therefore the triangles AHC, DHF are similar. In the same manner it appears, that AHB is similar to EHF, and CHB to EHD.

LET AC be divided at K, so that AK may be to KC, in the given ratio of DE to EF, the point K will thus be given. Join HK meeting the circle in G. The triangles AHC, DHF being similar, and having AC, DF, similarly divided at K, E, the triangles AHK, KHC will therefore be similar to DHE, EHF, which have been proved similar to BHC, AHB; therefore the angle AHB is equal to CHK or CHG, and the arch AB is equal to CG, hence G is a given point, and K being given, the line GH will be given by position; therefore the point H is given which was to be found.

CONSTRUCTION. Describe a circle through the points A, B, C, let AB, BC, be the lines upon which D and F, the extremities of the indeterminate line, are to be placed, and let AC be the line which is to meet it in E, so that DE may be to EF, in the given ratio of *de* to *ef*. Find K, so that AK may be to KC as *de* to *ef*, draw BG parallel to AC, meeting the circle in G, join GK meeting the circle in H, the point which may be found; that is, if any circle be described through H, and B the intersection of any two of the given lines, to meet them in D and F, and if DF be joined, meeting the remaining line at E, the line DF shall be divided at E, similarly to the given line *def*.

LET AH, BH, CH be joined, also DH, EH, FH. The angle HDF or HDE is equal to HBF, that is, to HAE, the points H, A, D, E are therefore in a circle, now the points H, B, D, F are

are in a circle, therefore (Lemma.) the points H, C, E, F are also in a circle. The angle HDE is equal to HBC, that is, to HAK, and since HEF is equal to HCF, therefore HED is equal to HCB, that is, to HGB or HKA; hence the triangles HDE, HAK are similar, and since HFE is equal to HCK, the triangles HEF, HKC are also similar; therefore DE is to EF as AK to KC, that is, as *de* to *ef*.

COR. 1. The lines DH, EH, FH contain given angles, and have to each other the given ratios of AH, KH, CH.

COR. 2. The line DF cuts off segments DA, EK, FC from the given lines, adjacent to given points in them, and having to each other the given ratios of HA, HK, HC. For the angles HDB, HEK, HFC are equal among themselves, and since BCH or BGH, that is, AKH, is the supplement of each of the angles HCF, HAD, HKE, the angles HAD, HKE, HCF are equal among themselves, therefore the triangles HAD, HKE, HCF are similar, and AD, KE, CF are proportional to the given lines AH, KH, CH.

PROP. VI. PORISM, Fig. 11. PL. II.

LET AB, AC, BE, DE be four straight lines given by position; a point P may be found, such, that if any circle be described through it and B, any of the six intersections of the given lines, to meet the lines through whose intersection it passes in G and L, and if GL be joined, meeting the remaining lines in H and K, the segments GH, HK, KL have given ratios to one another, which ratios are to be found.

BECAUSE, by hypothesis, the points P, A, G, H are in a circle, and also the points P, F, H, K, it will appear, as in the analysis of last proposition, that P is in a circle described about the triangle ADF; in the same way it will be found, that P must be in circles described about each of the triangles ABC, DBE,

FCE. Therefore, that the proposition may be universally true, these four circles must intersect one another at the same point.

ABOUT any two of these triangles, as ABC, DBE, let circles be described, the point P must be at their intersection.

BECAUSE ADF is a triangle, and through two of its angles A, D, circles are described, meeting each other at B, a point in AD, therefore (Lemma.) P, their other intersection, and the points F, C, E, are in a circle; and because FCE is a triangle, and circles pass through C, E, two of its angles, and meet each other at B, a point in CE, therefore (Lemma.) the points P, A, D, F are in a circle. Thus, it appears, that circles described about each of the four triangles ADF, ABC, DBE, CFE, pass through the same point P as was to be investigated. It remains to inquire, whether the ratios of GH, HK, KL to one another be given. Join PB, PC, PE, also PG, PH, PK, PL. The angle GPH is equal to GAH, that is, to BPC, and PGH is equal to PBC, therefore the triangles BPC, GPH are similar, and the angle PHK is equal to PCE; but HPK is equal to HFK, that is, to CFE or CPE, hence the triangles HPK, CPE are similar, and PKL is equal to PEL. Now, if PN be drawn, so that the angle BPN may be equal to GPL, that is, to the given angle GBL, it is evident that the point N is given, and will be in a circle passing through P, and touching AG at B; the angles NPE, LPK will thus be equal, and the triangles NPE, LPK similar. Since, therefore, the triangles BPC, CPE, EPN are similar to GPH, HPK, KPL, it follows, that BN, GL are similarly divided by the given lines CH, EK, therefore the ratios of GH, HK, KL are the same with the given ratios of BC, CE, EN.

CONSTRUCTION. About ABC, DBE any two of the four triangles formed by the given lines, let circles be described, they will meet each other at P, the point which is to be found.

THROUGH

THROUGH P and B, the intersection of any two of the given lines, let a circle be described to touch one of them at B, and cut the other at N, the line BN will be given, and the ratios of GH, HK, KL, the same with the given ratios of BC, CE, EN to one another.

THE synthetical demonstration follows readily from the analysis, and for the sake of brevity is here omitted.

COR. 1. The lines PG, PH, PK, PL, contain given angles, and have to each the given ratios of PB, PC, PE, PN.

COR. 2. The line GL cuts off from the given lines, segments BG, CH, EK, NL, adjacent to given points, and having to each other the given ratios of PB, PC, PE, PN. For the points P, A, G, H, being in a circle, the angle PGB is equal to PHC; and since P, F, H, K, are in a circle, the angle PHC is equal to PKE, which in like manner will be found equal to PLN. Now, the angles PBA, PCF, PEF, PNB are equal among themselves, therefore their supplements PBG, PCH, PEK, PNL are equal, and the triangles PBG, PCH, PEK, PNL are similar, therefore BG, CH, EK, NL are proportional to the given lines BP, CP, EP, NP.

PROP. VII. THEOREM, Fig. 12. Pl. III.

LET PGAB, PFAC, PEAD, &c. be any number of given circles, each of which passes through the same two points A, P; from A, either of these points let a straight line, given by position, be drawn, meeting the circles at B, C, D, &c. and another meeting them at E, F, G, &c. Let straight lines GB, FC, ED, &c. be drawn, joining these points, so as to form, with the lines passing through A, triangles GAB, FAC, EAD, &c. in each of the circles. If, through P, the common intersection of the circles, and Q, the intersection of

of any two of the lines, a circle be described to meet them in K and L, a line joining KL, and meeting the remaining lines, will be divided by them into segments HK, KL, LM, MN, &c. having to each other given ratios.

LET Q, R, S, &c. be the remaining intersections of GB, FC, ED, &c. Because GRE is a triangle, and circles PGAB, PEAD pass through G, E, two of its angles, and meet at A, a point in GE, the points P, R, B, D, are in a circle, (Lemma.) in the same way it appears, that circles may pass through P, S, C, D, and P, Q, B, C, &c. Because it is now proved, that in the triangle CDS, a circle may pass through P, C, B, Q, and another through P, D, B, R; therefore the points P, S, R, Q, are in a circle. (Lemma.) Thus it may be shewn, that circles described about each of the triangles, formed by the intercepted segments of the straight lines, will all pass through the same point P. From P draw straight lines to the points of intersection of one of the given lines, with all the others, as PA, PB, PC, PD, &c. Join PH, PK, PL, PM, PN, &c.

SINCE P, Q, K, L, are in a circle, the angle BKP is equal to CLP; now, the angles PBG, PCF, are each equal to PAG; therefore the angles PBK, PCL, are equal, and the triangles PBK, PCL, similar; hence KP is to PL as BP to PC; now the angle KPL is equal to KQL, that is, to BPC; therefore the triangles KPL, BPC, are similar, and the angle PLM will be equal to PCD. But the points P, S, C, D, having been proved to lie in a circle, if PS be joined, the angle PCD will be equal to PSD, therefore PLM is equal to PSD or PSM, hence the points P, S, L, M are in a circle. In the same way it may be shewn, that P, G, H, K are in a circle, as also P, D, M, N, &c. and that the triangles PAH, PDM, &c. are each similar to PBK and PCL, and hence that PHK is similar to PAB, and PLM to PCD, &c. Through P describe a circle to touch AG at A, and meet AD in

in V, which will be a given point, since GA, AD, are given by position.

JOIN PV, the angle PVA is equal to PAE or PDS, that is, (P, D, M, N being in a circle) to PNM, and PDV is equal to PMN, the triangle PMN is therefore similar to PDV; and since the angle PVA is equal to PDS, also PNV to PMD, the triangles PDM, PVN are similar. Thus it appears, that HN and AV are similarly divided by the lines BK, CL, DM, &c.; now, the points A, B, C, D, V, &c. are given; therefore the ratios of HK, KL, LM, MN, &c. to one another are given. Q. E. D.

COR. 1. The lines PH, PK, PL, PM, PN, &c. contain given angles, and have to each other the given ratios of PA, PB, PC, PD, PV, &c.

COR. 2. The line HN cuts off from the given lines, segments HA, KB, LC, DM, VN, &c. adjacent to given points, and having also to one another the given ratios of PA, PB, PC, PD, PV, &c.; for the triangles PAH, PBK, PCL, PDM, PVN, &c. have been proved equiangular; and therefore AH, BK, CL, DM, VN, &c. are proportional to PA, PB, PC, PD, PV, &c. *.

PROP. VIII.

* It may be proper to remark here, that, in the preceding propositions, the straight lines given by position, as well as the indeterminate straight line, which is cut by them into segments, having to each other given ratios, and which also cuts off from them segments adjacent to given points, and having to each other given ratios, are tangents to a parabola, of which the point that is required to be found is the focus. This consideration suggests some curious propositions, relating to tangents to the parabola. Some of them have been observed by Dr HALLEY, in his translation of the *Sectio Rationis* of APOLLONIUS.

ONE very obvious application of the propositions above hinted at, is to describe parabolas that shall pass through given points, and touch straight lines given by position.

PROP. VIII. PORISM, Fig. 13. Pl. II.

LET CA, CB, AB be three straight lines given by position, a point H may be found, such, that if through H, and B, C, any two of the intersections of these lines, there be described circles HBEF, HCDE, to meet each other at E, a point in BC, and the remaining lines at D and F. If DE, EF, DF be joined, the triangle DEF shall be similar to a given triangle *def*, and shall have its angles upon the given lines in a given order.

BECAUSE circles are described through C, B, and meeting each other at E, a point in CB, therefore their other intersection H, the remaining angle A, and the points D, F, are in a circle. (Lemma.) Let a circle be described through H, C, A, to meet CB in G, and another through H, B, G, to meet AB in K. Join HA, HG, HK, also HD, HE, HF. The angles ADH, GEH, KFH, are equal to one another, and the angles CAH, CGH, BKH are equal, therefore HAD, HGE, HKF are equal, and the triangles HAD, HGE, HKF are similar; therefore DH is to HE as AH to HG, and EH is to HF as GH to HK; now, the angles DHE, EHF are equal to DCE, EBF, that is, to AHG, GHK; hence the quadrilateral HDEF is similar to HAGK, and the triangle DEF is similar to AGK; now, the angles EDF and DEF are given by hypothesis, therefore GAK and AGK are given; but A is a given point, and AK is given by position, therefore AG and the point G are given; therefore GK and the point K are also given, and H, the intersection of the given circles GAC, GBK, will be given, which was to be found.

CONSTRUCTION. Take a given point, which, to render the construction more simple, may be at A, one of the intersections
of

of the given lines. Let AG, GK be so drawn as to form a triangle AGK, similar to the given triangle *def*, and having its angles placed upon the given lines, in the given order. Through A, G, any two of its angles, and C, the intersection of the lines upon which they are placed, describe a circle; through G, K, and B, the intersection of CG, AK, let another circle be described, meeting the former in H, the point to be found, which will also be in a circle passing through K, and touching CA at A.

THE demonstration follows easily from the preceding analysis.

COR. 1. The lines HD, HE, HF contain given angles, and have to each other the same ratios, with the given lines HA, HG, HK.

COR. 2. The lines AD, GE, KF have also to each other the given ratios of HA, HG, HK.

PROP. IX. THEOREM, Fig. 14. Pl. III.

LET *Ea*, *Eb*, *Fc*, *Gd*, &c. be any number of straight lines given by position. Let P be a given point. Through P, and E, the intersection of any two of the given lines, let a circle be described to meet them in A and B; through P, B, and H, the intersection of *Bb*, with one of the remaining lines, let a circle be described to meet that line in C. Through P, C, and K, the intersection of *Cc*, with one of the remaining lines, let a circle be described to meet that line in D, and so on if there be more lines. Join AB, BC, CD, &c. DA. The rectilineal figure ABCD, &c. is given in species.

TAKE *a*, a given point in EA, through P, E, *a*, describe a circle to meet EB in *b*, through P, H, *b*, describe a circle to meet HC in *c*, through P, K, *c*, describe a circle to meet KD in *d*, and so on if there be more lines. Join Pa, PA, also PB, Pb, PC,
P P_c,

Pc , PD , Pd , &c. Because the points P , E , A , B , are in a circle, the angle PAa is equal to PBb ; now PaA is equal to PbB ; for PaE is equal to PbE , the triangles PaA , PbB are therefore similar. In the same manner it may be shewn, that PbB is similar to PcC , and that again to PdD , &c. Therefore PA is to PB as Pa to Pb , and PB to PC as Pb to Pc , and PC to PD as Pc to Pd , &c.; now the angles APB , BPC , CPD , &c. are equal to AEB , BHC , CKD , &c. that is, to aPb , bPc , cPd , &c. therefore if ab , bc , cd , &c. Ad be joined, the rectilineal figure $PABCD$, &c. is similar to $Pabcd$, &c.; and leaving out the similar triangles PAD , Pad , the rectilineal figure $ABCD$, &c. is similar to $abcd$, &c. Now the points P , E , a , being given, the circle passing through them is given; therefore b is a given point; in like manner c , d , &c. are given points; therefore the figure $abcd$, &c. is given; therefore $ABCD$, &c. to which it is similar, is given in species. Q. E. D.

COR. 1. The lines PA , PB , PC , PD , &c. contain given angles, and have to each other the given ratios of Pa , Pb , Pc , Pd , &c.

COR. 2. The segments Aa , Bb , Cc , Dd , &c. of the given lines, adjacent to the given points a , b , c , d , &c. have also to each other the given ratios of Pa , Pb , Pc , Pd , &c.

COR. 3. If there be any number of straight lines given by position, there may be innumerable rectilineal figures similar to one another, and having their angles upon the straight lines given by position.

PROP. X. PORISM, Fig. 15. Pl. III.

LET A and B be two given points in the circumference of a given circle, C be a given point in KC , a straight line given

given by position. There may be found a straight line KD, given by position, and also a given point D in that line, such, that if AE, BE be inflected to any point in the circumference of the given circle, they shall cut off from KC, KD, segments FC, GD, adjacent to the given points, and having to each the given ratio of α to β .

SUPPOSE the line KD, and the point D to be found. If AH, BH be inflected to the circle, so that AH may pass through C, then BH must pass through D, the point which may be found, otherwise the proposition would not be universally true. Now, C being given, the point H, and the line BH, will be given by position. Let AL be drawn parallel to KC, then BL must be parallel to KD, the line to be found; hence it appears, that the angle GKF is equal to ALB, that is, to GEF; therefore the points E, K, G, F are in a circle, and the angle DGB is equal to CFA; now DBG is equal to CAF; therefore the triangles DBG, CAF are equiangular, and AC is to BD as CF to DG, that is, by hypothesis, as α to β ; now AC is given, and BH is given by position, therefore the point D is given, but BDG is equal to the given angle ACF, therefore DG is given by position.

CONSTRUCTION. Join AC, meeting the circle in H. Join BH, and, as α is to β , so let AC be to BD. Through H, D, C describe a circle to meet FC in K. Join DK; then D is the given point, and DK is the line given by position, which are to be found; that is, if AE, BE be inflected to any point in the circumference, to meet the given lines in F, G; CF shall be to DG as AC to BD, or as α to β . The demonstration is easily derived from the analysis,

THE foregoing propositions, in one point of view, may be considered as exhibiting innumerable solutions of certain geometrical problems of the indeterminate kind, to each of which,

if some condition, unconnected with the hypothesis of the proposition, be added, there will be formed a problem perfectly limited in its nature.

THE method of applying the porisms to the solution of many problems is obvious enough; and, as some of these may be of a very extensive nature, and such as many others can be reduced to, therefore the utility of the porisms will by this means be greatly extended. The condition that may be joined to the hypothesis of each porismatic proposition, it is evident, may be greatly varied: And, hence, it were easy to form abundance of problems, differing from any hitherto proposed: but this would extend the paper to too great a length. We shall therefore only give a few examples, of which, let the first be the *Scēlia Rationis* of the ancient geometers.

PROP. XI. PROBLEM, Fig. 16. Pl. III.

Two straight lines AB, AC are given by position, and two points B, C are given in these lines. It is required to draw a line through P, a given point, without them, to meet them in D and E, so that BD may have to CE the given ratio of M to N.

BECAUSE the ratio of BD to CE is given; if a circle be described through the points A, B, C, there is given a point H in the circumference, such, that the points A, H, D, E are in a circle, (Prop. 1.) therefore if HD, HA be joined, the angle HDP is equal to HAE, that is, to a given angle; now H and P are given points, therefore D is in the circumference of a given circle, but it is also in AB, a line given by position; therefore D is a given point, and PE is given by position, which was to be found.

CON-

CONSTRUCTION. Through A, B, C describe a circle; inflect BH, CH to the circumference, so that BH may be to CH in the given ratio of BD to CE, or of M to N*, thus H will be a given point. If the segments BD, CE to be cut off, are to lie in the same direction with AB, AC, the point H must be found in the same segment with BAC; but if they are to lie in contrary directions, then H must be taken in that segment upon which BAC stands. Join AH and PH, upon which describe a segment of a circle, that may contain an angle equal to HAC, which is given. This circle may cut AB in two points D, d. Join PD and Pd, meeting the remaining line in E and e; these lines cut off segments BD, CE, or Bd, Ce, having to each other the given ratio of BH to HC, or of M to N.

JOIN HD, HE. Because the angle PDH is by construction equal to HAE, the points A, H, D, E are in a circle; therefore the angle HEA is equal to HDA, that is HDB is equal to HEC; now, HBD is equal to HCE, for HBA is equal to HCA, therefore the triangles HCE, HBD are similar, and BD is to CE as BH to HC, that is, by construction, as M to N.

It is evident that this problem may admit of four solutions in general, if there be given no limitation with respect to the direction in which the segments are to be cut off from the given lines; but the data may be such as to render it capable of three and also of two solutions only.

THE next example shall be the *Sectio spatii* of the ancients.

PROP. XII. PROBLEM, Fig. 17. Pl. III.

Two straight lines AB, AC are given by position, and two points B, C are given in these lines. It is required to draw

a

* THE manner of doing this has been shewn in Prop. I.

a straight line through P, a given point, without them, to meet them in D and E, so that the rectangle BD, CE may be equal to a given space.

SUPPOSE that DE is drawn as required. Join PC which will be given in position and magnitude. Draw PF parallel to AC, and take F, so that the rectangle CP, PF may be equal to the given space, the point F will therefore be given; draw FL parallel to CP, meeting AB in K, and PD in L, then FL and the point K will both be given by position. The triangles LFP, PCE are similar; therefore LF is to FP as PC to CE, and the rectangle LF, CE is equal to the rectangle FP, PC, which, by hypothesis, is equal to the rectangle BD, CE, therefore FL is equal to BD; now, B and F are given points, and BK, FK are lines given by position; therefore (Prop. 1.) if a circle be described through K, B, F, there is a given point H in the circumference, such, that K, H, L, D are in a circle; therefore, if this point be found, and HD, HL, HK joined, the angle HDL is equal to HKL; therefore HDP is equal to HKF, that is, to a given angle; but H and P are given points, therefore D is in the circumference of a given circle; but it is also in a straight line given by position; therefore D is a given point, and PD is given by position.

CONSTRUCTION. Join P and C, either of the given points in the given lines; draw PF parallel to CA, and take F, so that the given space may be the rectangle CP, PF. Draw FL parallel to CP, meeting AB in K, and through the points F, B, K describe a circle. Find H in the circumference, so that BH may be equal to FH. Join HK and HP, upon which describe a segment of a circle, that may contain an angle equal to HKF; this circle may meet AB in two points D, d. Join PD and Pd, meeting

ing AC in E and ϵ . The rectangles BD, CE, and B δ , C ϵ , are each equal to the given rectangle FP, PC.

LET ED meet FK in L, join HL, HD. Because by construction the angle HDP is equal to HKF; therefore HDL is equal to HKL; therefore the points H, K, D, L, are in a circle, and the angle HLK is equal to HDK, that is HLF is equal to HDB, now HFL is equal to HBD, also HF is equal to HB; therefore the triangles HFL, HBD are in all respects equal, and FL is equal to BD. Again, the triangles LFP, PCE are similar, therefore FL is to FP as CP to CE, and the rectangle FL, CE is equal to the rectangle FP, PC, but FL is equal to BD, therefore the rectangle BD, CE is equal to the rectangle FP, PC, that is to the given space. In the same way it may be shewn that the rectangle B δ , C ϵ is equal to FP, PC.

PROP. XIII. PROBLEM, Fig. 18. PL. IV.

FOUR straight lines DB, DF, CG, BG are given by position, it is required to draw a line to meet them in the points N, O, P, Q, so that the line NQ may be divided at these points, similarly to a given divided line $n o p q$.

SUPPOSE the line NQ drawn as required. Because DB, DF, BF are three straight lines given by position, and that NQ is divided by one of them at O into segments, having to each other a given ratio, if a circle be described through the points B, D, F, there is a given point E in the circumference, such, that the points E, B, N, Q are in a circle, (Prop. 5.) Again, because CB, CG, BG are three lines given by position, and NQ is divided by one of them at P into segments, having to each other a given ratio, if a circle be described through B, C, G, there is a given point A in the circumference, such, that A, N, B, Q are in a circle, (Prop. 5.) Thus it appears, that there are given three

three points A, E, B in a circle, passing through N and Q, therefore NQ is given by position.

CONSTRUCTION. Let DB, BG be the lines upon which the extremities of NQ are to be placed. About the triangles BDF, BCG, describe circles, draw BH parallel to FD, meeting the circle DBF in H, and draw BK parallel to CG, meeting the circle CBG in K. In DF find L, so that DL may be to LF as no to oq , and in CG find M, so that CM may be to MG as np to pq , join HL meeting the circle DBF in E, join also KM meeting the circle CBG in A. Through the points A, E, B describe a circle meeting DB, BG in N and Q, join NQ meeting the other lines in O and P, and NQ shall be divided similarly to nq .

It has been proved in Prop. 5. that the point E being found as above, if any circle pass through E and B, and meet DB, GB in N and Q, the line joining NQ shall be divided at O, so that NO will be to OQ as DL to LF, that is by construction as no to oq . Likewise, that the point A being found as above, if any circle be described through A and B, to meet DB, BG in N and Q, the line NQ being drawn, shall be divided at P, so that NP will be to PQ as CM to MG, that is by construction as np to pq . Hence, it is obvious, that NQ is divided similarly to nq .

It may be remarked, that the preceding construction points out very clearly, a circumstance which appears to have escaped the notice of some Mathematicians that have given solutions of the problem, with a view to its application to Astronomy. It is that the given ratios of NO, OP, PQ, to one another may be such as to render the problem indeterminate. Now, this it is evident will be the case, if the points A, E shall both fall at \mathcal{A} the intersection of the circles. This case forms Prop. VI. of this paper, so that it may be sufficient to add here, that the ratios which

which render the problem indeterminate, are those which are required to be found, in the proposition just now quoted.

PROP. XIV. PROBLEM, Fig. 19. PL. IV.

THREE straight lines AB, AC, BD are given by position, and P is a given point. It is required to draw PE to meet BD in E, and PG meeting AB in F, and AC in G, so that the angle EPG may be given, and so that EP may have to FG the given ratio of α to β .

SUPPOSE the lines drawn as required. In GP take PH equal to FG, therefore the ratio of EP to PH will be given, now the angle EPH is given, therefore H is in a straight line given by position, (Apoll. Loci Plani, Lib. 1. Prop. 6.) let this line be LC. Bisect PF in K, then because P is a given point, and AB is given by position, the point K will be in a straight line given by position, (Loci Plani, Lib. 1. Prop. 4.) let this line be LM. Because GF is equal to PH, and FK to PK, therefore GK is equal to KH, but the lines ML, MC, CL are given by position, therefore, (Prop. 5.) a given point N may be found in the circumference of a circle passing through M, C, L, such, that the points N, M, G, K are in a circle, therefore if this point be found, and NG, NM joined, the angle NGK or NGP is equal to the given angle NML, now N and P are given points, therefore G is in the circumference of a given circle, but it is also in a straight line given by position, therefore the point G is given.

CONSTRUCTION. Find LC a straight line given by position, such, that if PE, PH be drawn meeting BD, CL, and containing an angle EPH equal to the supplement of the given angle

Q

EPG,

EPG, the ratio of EP to PH may be the same with the given ratio of α to β . (Loci Plani, Prop. 6. Lib. 1.) Find also a straight line LM given by position, such, that PF drawn to any point in AB, may be bisected by it in K. Through L, M, C, the intersections of the given lines LM, AC, LC, describe a circle. Draw CO parallel to LM, meeting the circle in O; bisect ML in Q; join OQ meeting the circle in N; join NM, and inflect NG, PG to AC, so that the angle NGP may be equal to NML; draw PE, so that the angle EPG may be such as is required.

LET GP meet CL in H, and AB in F, also LM in K; join NH, NK, NL. Since NGP is equal to NML, the points N, K, G, M are in a circle, and the angle NKH is equal to NMG or NMC, that is to NLH; therefore the points N, K, L, H are in a circle, and the angle NHK is equal to NLQ; now NKH is equal to NMG or NOC, that is (OC being parallel to ML) to NQL; therefore the triangles NKH, NQL are similar. In like manner it appears, that NKG, NQM are similar; therefore ML and GH are similarly divided at Q and K, but ML is bisected at Q; therefore GH is bisected at K; now PF is also bisected at K; therefore GF is equal to PH, and EP is to FG as EP to PH, that is, by construction, as α to β .

PROP. XV. PROBLEM, Fig. 20. PL. IV.

THREE straight lines AB, AC, BC are given by position, and three points D, E, F are given in these lines. It is required to draw a straight line GHK to meet them, so that DG, EH, FK may have to each other the given ratios that P, Q, R have among themselves.

Suppose

SUPPOSE that the line is drawn as required. Because the ratio of DG to EH is given, there is given (prop. 1.) a point M in the circumference of a circle passing through A, D, E, such, that the points A, M, G, H are in a circle. If this point be found, and MG, MH, MD, ME joined, the angle GMH is equal to GAH or to DME. Also if MA, DE be joined, the angle MHG is equal to MAG or to MED. Therefore the triangle MHG is similar to the given triangle MED, and the angle MHG is given.

IN like manner, because the ratio of EH to FK is given, there is given a point N in the circumference of a circle passing through E, C, F, such, that N, C, H, K are in a circle. If NH, NK, NE, NF, NC, EF be joined, it may be proved, in the same way, that the triangle NHK is similar to NEF, hence the angle NHK is given. Now, the angles MHG, NHK being each proved to be given, the angle MHN is given, and the points M, N being also given, the point H is in the circumference of a given circle; but it is also in a straight line given by position; therefore the point H is given, and the angles MHG, NHK being given, the line GK is given by position, which was to be found.

CONSTRUCTION. Through the points A, D, E describe a circle, and inflect DM, EM to the circumference, so that DM may be to EM as P to Q. Describe also a circle through C, E, F, and inflect EN, FN to the circumference, so that EN may be to FN as Q to R. Join DE, EF, and inflect MH, NH to the straight line AE, so that the angle MHN may be the supplement of the sum of MED and NEF; draw HG, so that the angle MHG may be equal to MED; then NHK is equal to NEF.

JOIN MG, MA. Because the angle MHG is equal to MED or to MAG, the points M, A, H, G are in a circle; hence the angle MHE is equal to MGD; now MEH is equal to MDG; for MEA is equal to MDA; therefore the triangles MEH, MDG are similar, and DG is to EH as DM to ME, that is as P to Q.

In like manner it may be proved, that because the angle NEF is equal to NHK, the points N, C, H, K are in a circle, and hence that the triangle NEH is similar to NFK; hence EH is to FK as EN to FN, that is as Q to R. Therefore GHK is drawn as required.

PROP. XVI. PROBLEM, Fig. 20. PL. IV.

It is required to describe a triangle DEF similar to a given triangle *def*, having one of its sides EF passing through P a given point, and having its angles in a given order upon three straight lines AB, AC, BC given by position.

THE construction of this problem follows readily from the 8th proposition, as follows:

DRAW AG, GK, so as to form a triangle AGK, similar to the given triangle *def*, and having its angles upon the given lines in the given order.

THROUGH A, G, any two of its angles, and C, the intersection of the lines upon which they are placed, describe a circle. Through G, K, and B, the intersection of GC, KA, describe a circle meeting the former in H. From the points H, P inflect HE, PE to CB, so that the angle HEP may be equal to HGK; let PE meet AB in F. Through H, C, E describe a circle to meet CA in D; join DE, DF, and the triangle DEF shall be similar to AGK or to *def*.

JOIN HD, HF, HA, HK, HB, HC. Because, by construction, the angle HEF is equal to HGK or to HBK, the points H, B, E, F are in a circle, and the angle FHE is equal to FBE or KHG, therefore the triangles EHF, GHK are similar. In like manner, because a circle passes through H, C, D, E, the angle DHE is equal to DCE or AHG, and HDE is equal to HCE or HAG, therefore the

the triangles EHD, GHA are similar. Now the triangle HEF was proved similar to HGK. Therefore the quadrilateral HDEF is similar to HAGK, and the angle DEF is equal to AGK; also DE is to EF as AG to GK; therefore the triangle DEF is similar to AGK or to *def*, as was required.

PROP. XVII. PROBLEM, Fig. 21. Pl. IV.

A and B are two given points in the circumference of a given circle. C and D are two given points in straight lines CE, DE given by position. It is required to inflect AF, BF to the given circumference, meeting the given lines in G and H, so that the rectangle CG, DH may be equal to a given space.

BECAUSE A and B are given points in the circumference of a given circle, and D is a given point in a line DE given by position, a line LM, and a point M in it, both given by position, may be found, (prop. 10.), so that BF, AF being inflected to any point in the circumference, meeting the given line DE in H; and the line LM, which may be found in N, the ratio of DH to MN, may be given.

SUPPOSE the line ML found, so that MN may be equal to DH, then the rectangle MN, CG is equal to DH, CG, which by hypothesis is given. Now A is a given point, and C, M are given points in straight lines given by position. Therefore the problem is now reduced to the 12th proposition of this paper.

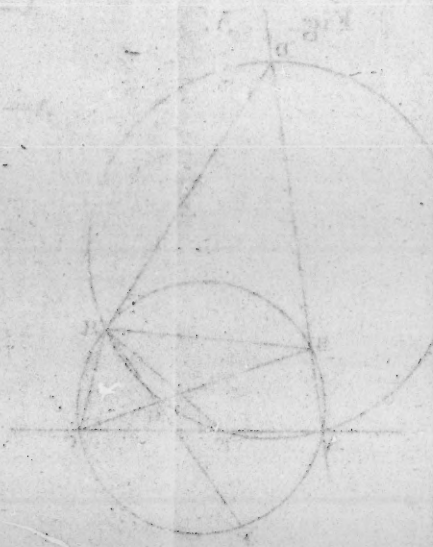
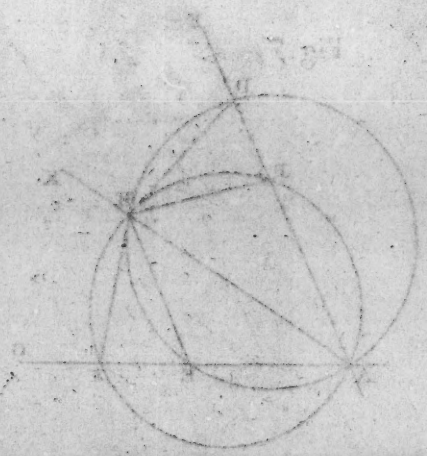
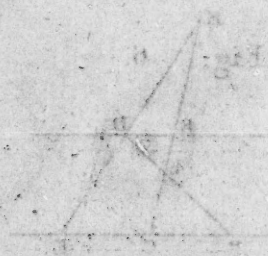
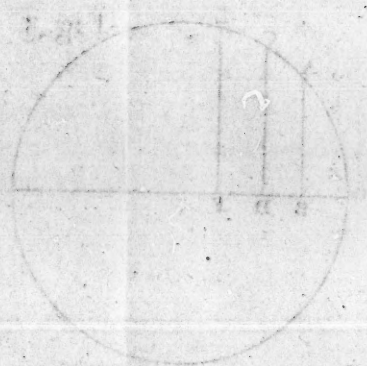
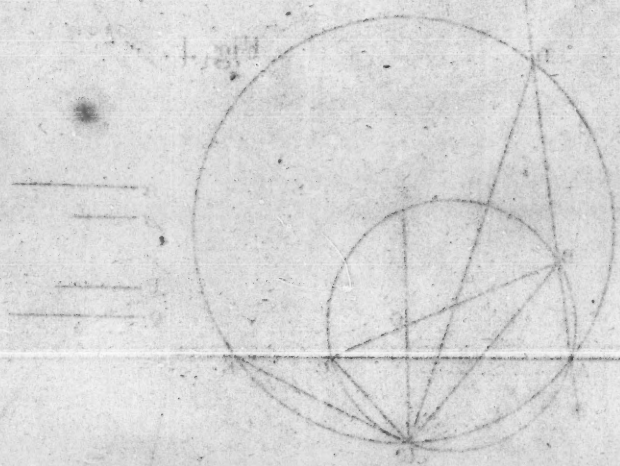
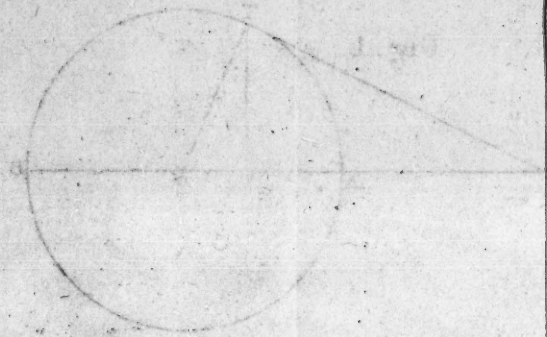
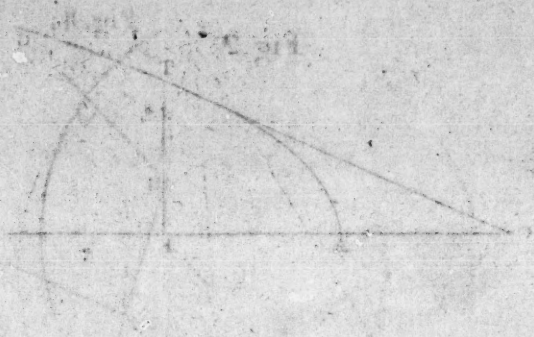
CONSTRUCTION. Join B and D, the given point, in the line whose segment is to be intercepted by BF. Let BD meet the circle in K; join AK, and take AM equal to BD. Through the points D, M, K describe a circle cutting DE in L, and AK in M. Join LM, and from the point A (by prop. 12.) draw a straight line to meet CE in G, and LM in N, so that the rectangle

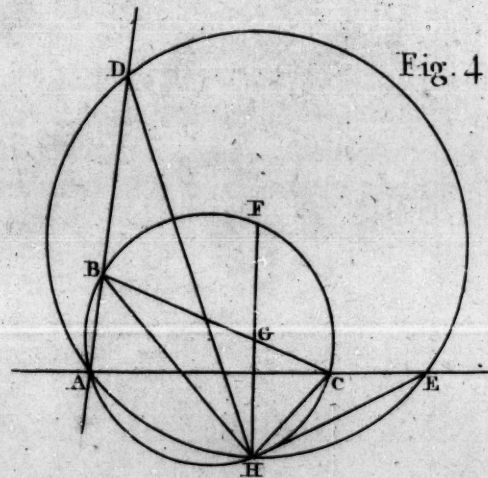
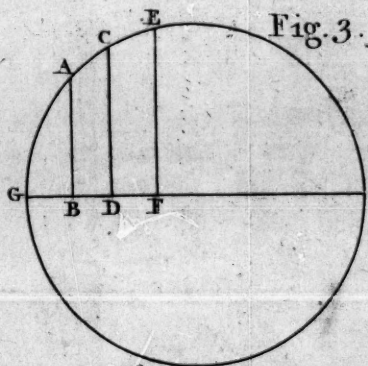
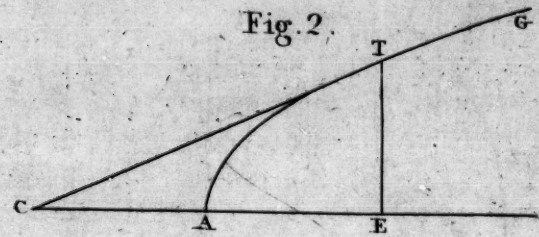
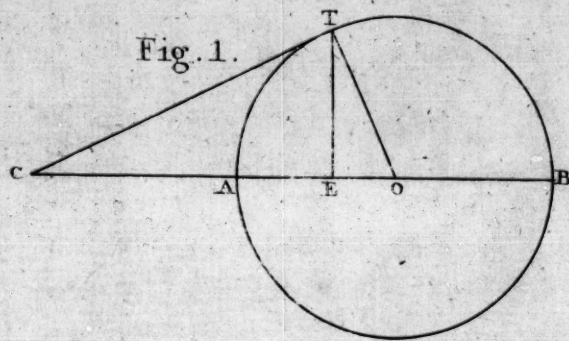
tangle MN, CG may be equal to that which is to be contained by CG, DH. Let AN meet the circle in F; join BF meeting DE in H.

THE angle HDB is equal to LMK or AMN, and the angle DBH is equal to MAN; now BD is equal to AM; therefore the triangles BDH, AMN are in all respects equal, and DH is equal to MN. Therefore the rectangle DH, CG is equal to MN, CG, that is, (by construction), to the given space as required.

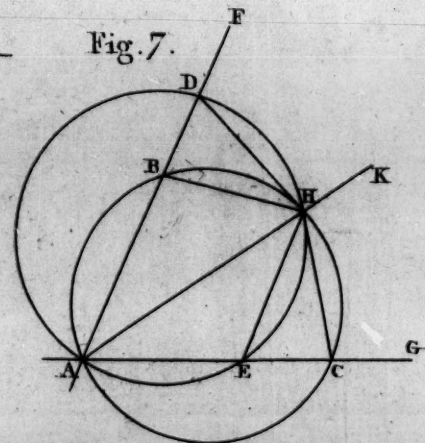
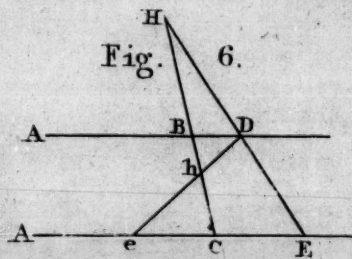
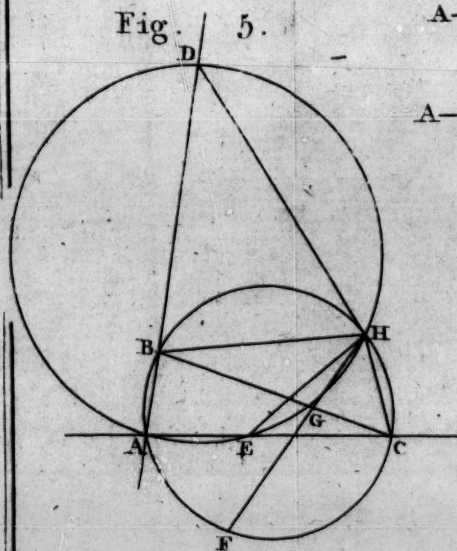
It is easy to see, how, in like manner, by drawing AGN, so that CG may be to MN in a given ratio, (prop. 11.), the lines BF, AF shall cut off segments DH, CG, having to each other a given ratio.

V.





α —
 β —
 P —
 Q —



M —

Fig. 8.

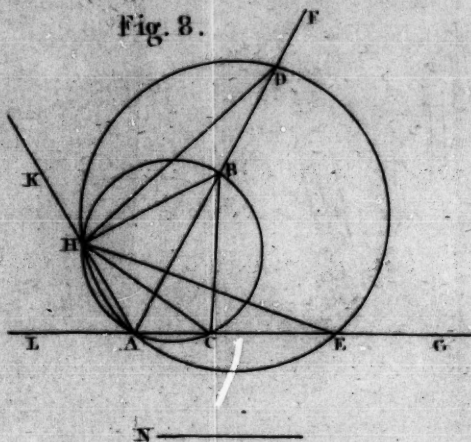


Fig. 11.

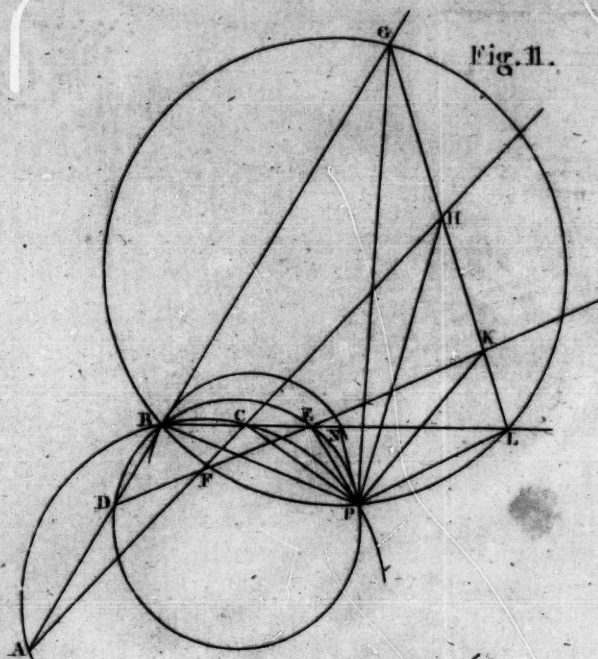


Fig. 9.

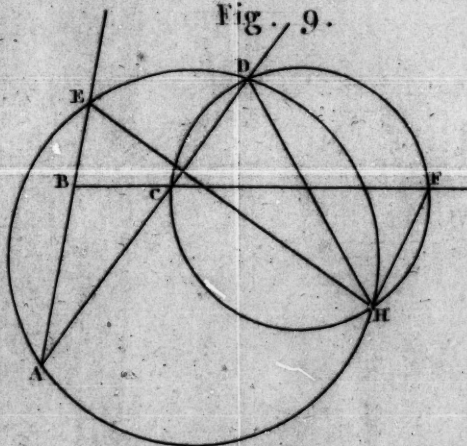


Fig. 10.

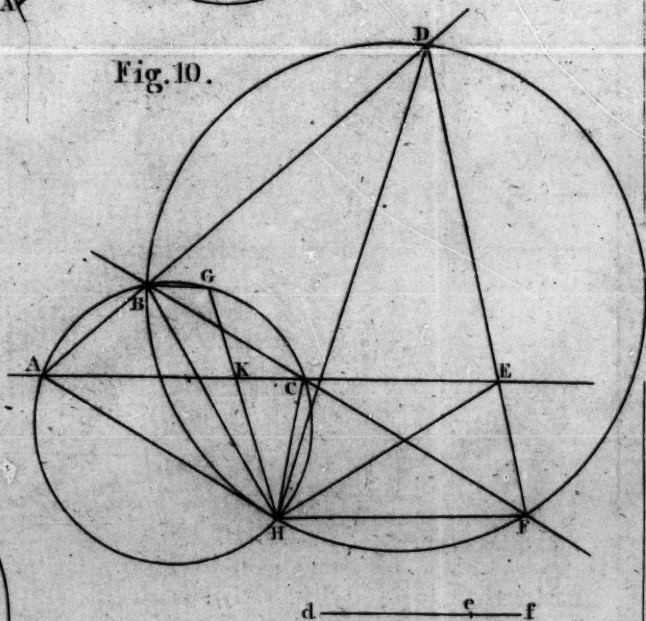


Fig. 13.

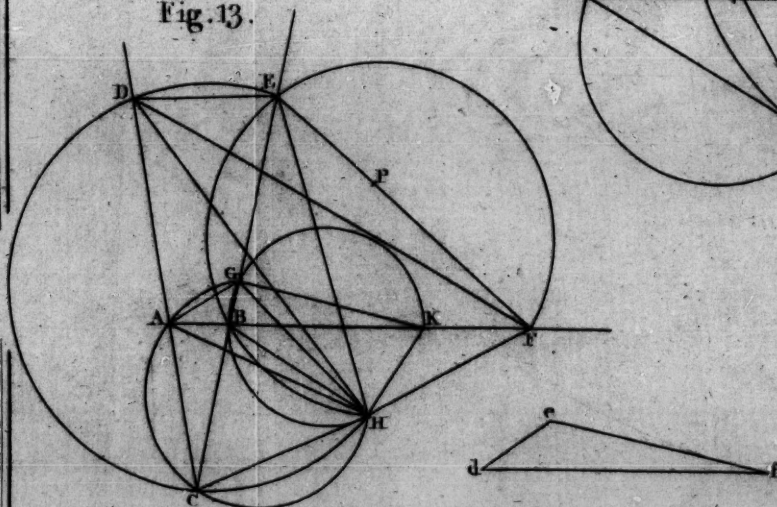


Fig. 12.

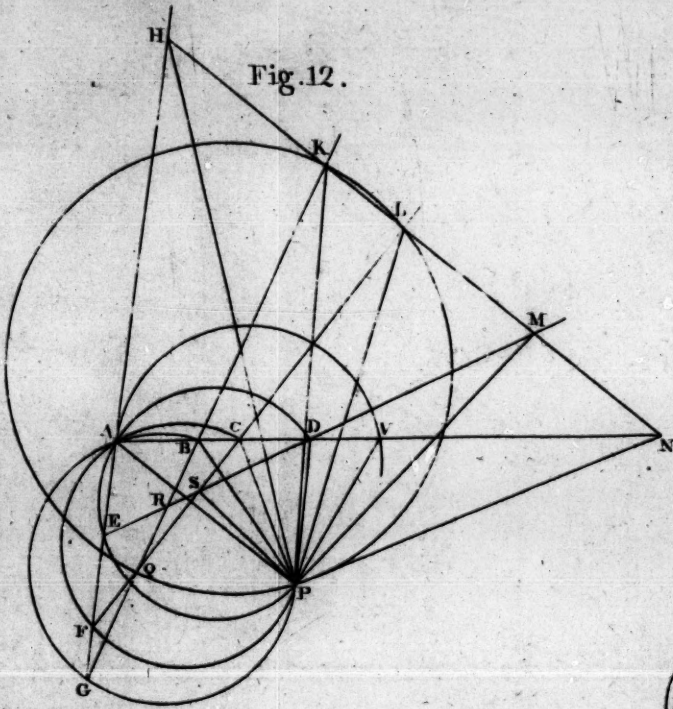


Fig. 15.

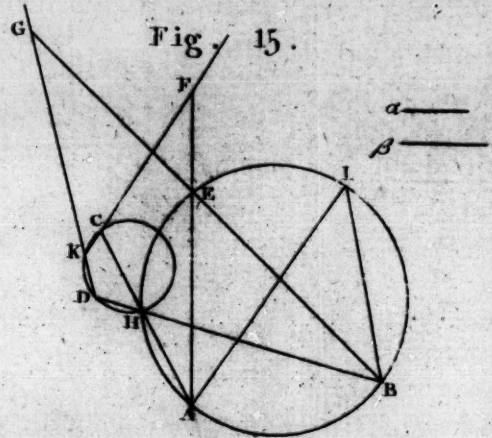


Fig. 17.

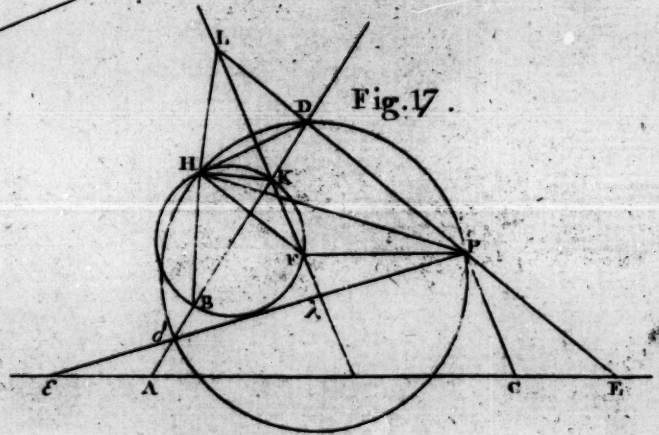


Fig. 14.

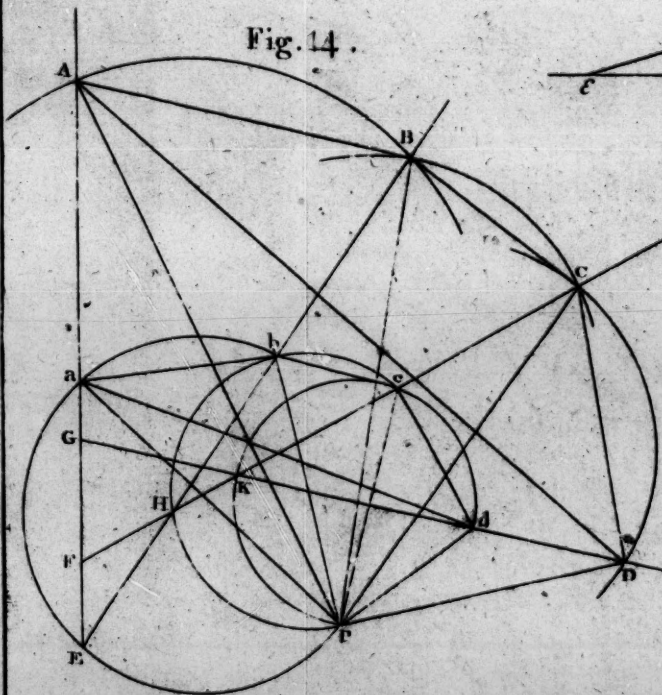


Fig. 16.

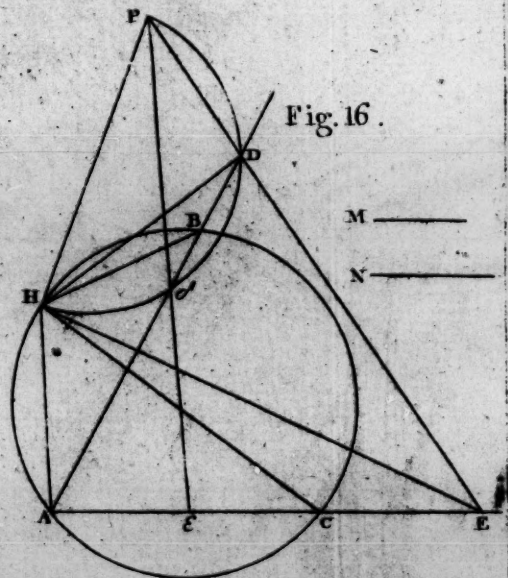


Fig. 18.

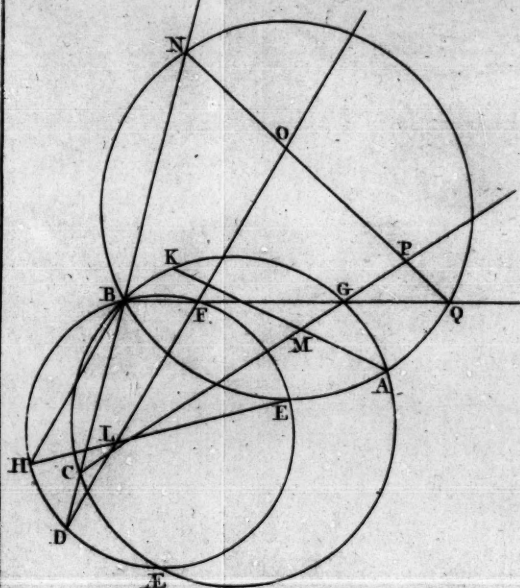


Fig. 19.

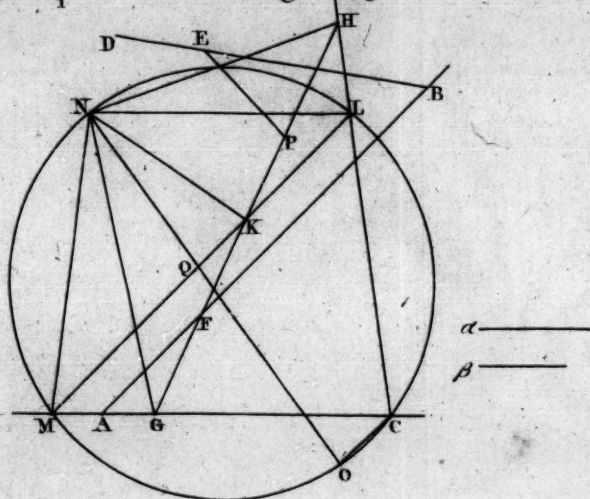


Fig. 21.

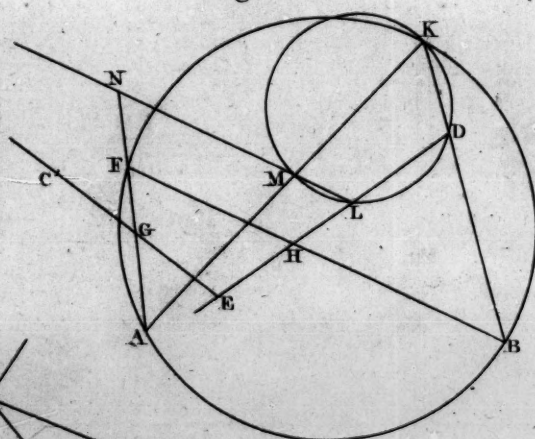
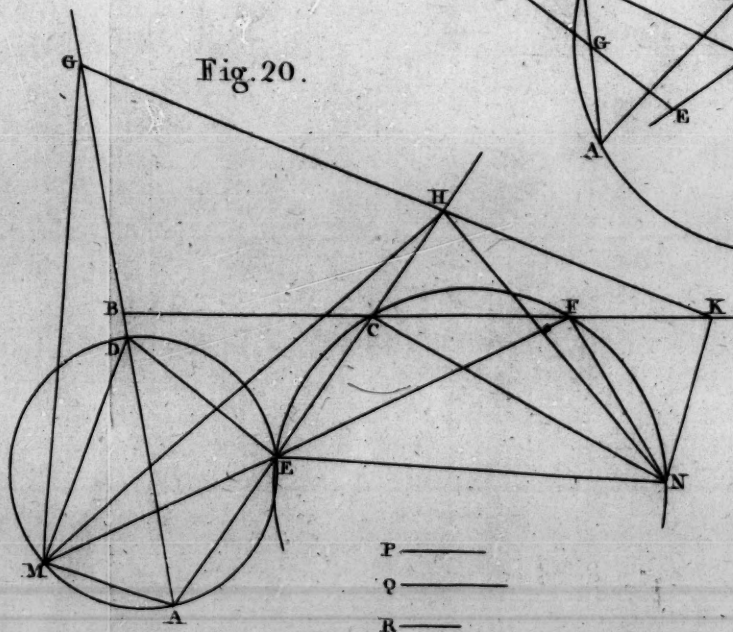


Fig. 20.



V. DETERMINATION of the LATITUDE and LONGITUDE of the
OBSERVATORY at ABERDEEN: In Two LETTERS from
ANDREW MACKAY, LL. D. & F. R. S. EDIN. to JOHN
PLATFAIR, F. R. S. EDIN. and Professor of Mathematics
in the University of Edinburgh.

LETTER I.

[Read 2d Dec. 1793.]

DEAR SIR,

Aberdeen, 18th September 1793.

SOME time ago I promised to send you the result of a series of observations, made to determine the situation of this place. Having, however, been much hurried of late, I am only able at present to transmit you the determination of the latitude, deduced from a series of observations of the sun's meridian zenith distances. With respect to the longitude, as soon as it is in my power, I will reduce some observations of occultations, and of the late solar eclipse, and send you the results.

THE following observations of the sun's meridian zenith distances were made with a moveable quadrant of two feet radius, constructed by Mr MACCULLOCH of London. This quadrant has two separate sets of divisions: the quadrantal arc of the inner set is divided into ninety degrees as usual; and the exterior arc is divided into ninety-six primary divisions; each of which

which is subdivided into eight equal parts; and the vernier gives one thirty-second part of a subdivision, or $13''$, 18. A ~~micrometer screw is attached to the vernier, which serves to regulate the motion of the index, and by which, the excess in seconds above the next less division of the vernier is shown.~~

EACH zenith distance was read off, at least, three times, both from the ninety and ninety-six arcs, and the means of each were taken. These served as a check on each other; however, the zenith distance, as given by the ninety-six arc only, is used for obvious reasons. The ninety-six arc was found to be about $12''$ less than 90° ; and the error of the line of collimation at the vertical radius was about a second and a half, subtractive.

As the transit instrument and quadrant were placed in adjacent rooms, it was therefore in my power to observe both the sun's transit and zenith distance the same day; however, the passage of the sun's west limb over the fifth wire, and that of the east limb over the first wire, were by this means lost. Hence, also, the zenith distance of one limb only of the sun could be observed; and the true zenith distance will be affected by the error of the sun's semidiameter, as given in the *Nautical Almanac*, and by the irradiation, which according to M. DU SEJOUR, exceeds three seconds.

THE middle wire in the telescope of the quadrant subtended an angle of no less than $20''$, 6; therefore, as it was scarce possible to bring the sun's limb exactly to the middle of the wire, I constantly made the lower edge of the wire a tangent to the sun's apparent lower limb. The zenith distances in the following table are the differences between those observed and the semidiameter of the wire, the tenths of a second being neglected.

THE fifth column of the table contains the error of the line of collimation, combined with that of the ninety-six arc, taking it for granted that this arc is accurately divided. In column sixth is the sun's semidiameter, from the *Nautical Almanac*, to the

nearest second. The next column contains the aggregate of the three preceding columns, and is the sun's apparent central zenith distance. The eighth column contains the mean refraction, answering to the apparent zenith distance of the sun's limb; hence the allowance for the contraction of the semidiameter at low altitudes is avoided. The next column contains the mean refraction reduced to the true, by the application of the corrections depending on the heights of the barometer and thermometer, as they are found in Table VIII. of my book on the Longitude: In column tenth is the sun's parallax; and the quantities in the two last columns, applied to those in column seventh, give these in column eleventh, being the true zenith distances of the sun's centre. The following column contains the sun's declination, reduced to the meridian of this place; and in the last column is the latitude.

left column is the latitude.											
Vol. IV.											
R											
Observed											

DETERMINATION of the LATITUDE

Observed Distances of the Sun's Upper Limb from the Zenith of the Observatory.

1786.	H. of Bar.	Th.	Zen. dist.	Err. Qua. +	Sun's Semid. add.	Appar. Zen. distance.	M. Ref.	Rcd. Ref.	Par. —	True Zenith distance.	Declination.	Latitude.
May 17.	29.78	48°	37° 26' 46"	3"	15 51"	37° 42' 40"	0 44"	0 44"	5"	37° 43' 19"	19° 25' 49"	57° 9' 8"
h June 3.	30.15	62 1/2	34 29 55	3	15 49	34 45 47	0 39	0 39	5	34 46 21	22 22 49	57 9 10
o — 4.	30.16	60	34 22 56	3	15 48	34 38 47	0 39	0 39	5	34 39 21	22 29 52	57 9 13
o — 5.	30.36	61	34 16 14	3	15 48	34 31 5	0 38	0 38	5	34 32 38	22 36 31	57 9 9
o — 7.	30.23	59	34 4 0	3	15 48	34 19 51	0 38	0 38	5	34 20 24	22 48 39	57 9 3
h — 8.	29.99	55 1/2	33 58 45	3	15 48	34 14 36	0 38	0 38	5	34 15 9	22 54 7	57 9 16
h — 10.	29.83	54 1/2	33 49 0	3	15 48	34 4 51	0 38	0 37	5	34 5 23	23 3 50	57 9 13
o — 11.	30.00	53	33 44 40	3	15 48	34 0 31	0 38	0 38	5	34 1 4	23 8 4	57 9 8
o — 12.	29.98	53 1/2	33 40 47	3	15 48	33 56 38	0 38	0 38	5	33 57 11	23 11 55	57 9 6
h — 15.	30.05	58	33 31 36	3	15 47	33 47 26	0 38	0 38	5	33 47 59	23 21 1	57 9 0
o — 18.	30.06	55	33 26 20	3	15 47	33 42 10	0 37	0 37	5	33 42 42	23 26 24	57 6 6
o — 19.	30.05	56	33 25 30	3	15 47	33 41 20	0 37	0 37	5	33 41 52	23 27 22	57 9 14
o — 20.	30.08	60	33 24 45	3	15 47	33 40 35	0 37	0 37	5	33 41 7	23 27 56	57 9 3
o — 21.	30.05	63	33 24 37	3	15 47	33 40 27	0 37	0 37	5	33 40 59	23 28 5	57 9 4
h — 22.	29.89	65	33 24 53	3	15 47	33 40 43	0 37	0 36	5	33 41 14	23 27 49	57 9 3
h — 24.	29.70	65	33 26 42	3	15 47	33 42 32	0 37	0 36	5	33 43 3	23 26 2	57 9 5
o — 25.	29.86	66	33 28 10	3	15 47	33 44 0	0 37	0 36	5	33 44 31	23 24 32	57 9 3
o — 27.	29.65	58	33 32 18	3	15 47	33 48 18	0 38	0 37	5	33 48 50	23 20 16	57 9 6
o July 3.	30.69	57	33 50 13	3	15 47	34 6 3	0 38	0 38	5	34 6 36	23 12 58	57 9 4
o — 3.	29.71	63	33 54 56	3	15 47	34 10 46	0 38	0 37	5	34 11 16	22 57 42	57 9 0
o — 5.	30.29	61 1/2	34 5 52	3	15 47	34 21 42	0 38	0 38	5	34 22 15	22 46 38	57 9 13
h — 15.	30.31	66	34 22 36	3	15 47	34 38 26	0 39	0 39	5	34 39 0	21 29 59	57 8 59
o — 18.	30.31	63	35 52 56	3	15 47	36 8 46	0 41	0 41	5	36 9 22	20 59 35	57 8 57
o — 11.	30.02	57	36 26 30	3	15 48	36 42 21	0 42	0 42	5	36 42 58	20 26 0	57 8 58
o — 23.	29.55	65	36 50 43	3	15 48	37 6 34	0 43	0 43	5	37 7 11	20 1 53	57 9 4
h Aug. 3.	30.00	58	39 26 25	4	15 49	39 42 18	0 47	0 47	5	39 43 0	17 46 12	57 9 12
o — 4.	29.86	60	39 42 13	4	15 50	39 58 7	0 48	0 47	5	39 58 49	17 10 16	57 9 5
h — 5.	29.49	59	39 58 26	4	15 50	40 14 20	0 48	0 47	5	40 15 2	16 54 4	57 9 6
h — 16.	29.04	64	46 34 11	5	15 53	46 50 9	1 0	0 59	6	46 51 2	10 18 0	57 9 1
h — 30.	29.36	58	47 59 20	5	15 54	48 15 19	1 3	1 2	6	48 16 15	8 52 40	57 9 4
h — 31.	29.22	58	48 20 49	5	15 55	48 36 49	1 4	1 2	6	48 37 45	8 31 9	57 8 54
h Sept. 2.	29.44	60 1/2	49 4 44	5	15 55	49 20 44	1 5	1 3	6	49 21 41	7 47 27	57 9 8
o — 5.	29.93	54	50 11 15	2	15 51	50 27 16	1 9	1 10	7	50 28 19	6 40 58	57 9 16
h — 20.	30.24	56	55 55 8	2	16 0	56 11 14	1 24	1 25	7	56 12 32	0 56 30	57 9 1
h — 21.	29.87	57	56 18 42	6	16 0	56 34 48	1 25	1 25	7	56 36 6	0 33 6	57 9 12
o — 27.	29.68	48	58 39 7	6	16 1	58 55 14	1 33	1 33	8	58 56 39	1 47 33	57 9 6
o Oct. 18.	30.34	47	66 37 58	7	16 7	66 54 12	2 13	2 17	8	66 56 21	9 47 18	57 9 3
h — 26.	30.42	44	69 26 57	8	16 10	69 43 15	2 31	2 37	8	69 45 14	12 36 48	57 8 56
h Dec. 2.	29.53	40	78 51 12	9	16 17	79 7 38	4 43	4 50	9	78 12 19	2 3 25	57 8 54
o — 10	29.34	44	79 46 27	9	16 18	80 2 54	5 9	5 11	9	80 7 56	22 59 8	57 8 48
o — 15.	29.36	37	80 6 29	9	16 19	80 22 57	5 19	5 27	9	80 28 15	23 19 17	57 8 58
o — 17.	29.54	34	80 11 7	9	16 19	80 27 35	5 21	5 34	9	80 33 0	23 24 5	57 8 55
o — 21.	30.02	28	80 14 50	9	16 19	80 31 18	5 23	5 45	9	80 36 54	23 28 3	57 8 51
o — 24.	30.24	35	80 12 55	9	16 19	80 29 23	5 22	5 41	9	80 34 55	23 26 4	57 8 51
o — 25.	30.08	28	80 11 19	9	16 19	80 27 47	5 21	5 43	9	80 33 21	23 24 27	57 8 54
1787.												
h Apr. 30.	29.56	44	42 2 15	4	15 55	42 18 14	0 51	0 52	6	42 19 0	14 50 3	57 9 3
o May 4.	29.81	52	40 50 53	4	15 54	41 6 51	0 49	0 49	6	41 7 34	16 1 25	57 8 59
o — 14.	30.06	46 1/2	38 11 40	4	15 52	38 27 36	0 44	0 45	5	38 28 16	18 40 40	57 8 56
o — 22.	29.87	59 1/2	36 26 33	3	15 50	36 42 26	0 42	0 41	5	36 43 2	20 25 49	57 8 51
o June 11.	30.12	60	33 41 35	3	15 48	33 57 26	0 38	0 38	5	33 57 59	23 10 59	57 8 58
o — 15.	29.61	56	33 32 11	3	15 47	33 48 1	0 38	0 37	5	33 48 33	23 20 43	57 8 56
h — 16.	29.66	60	33 29 53	3	15 47	33 45 43	0 38	0 37	5	33 46 15	23 22 42	57 8 57
h Sept. 1.	30.52	64	48 37 8	5	15 55	48 53 8	1 4	1 4	6	48 54 6	14 40	57 8 46
h — 19.	29.25	56	55 26 8	6	15 59	55 42 13	1 22	1 20	7	55 43 26	1 25 23	57 8 49
h — 22.	29.49	56	56 36 9	6	16 0	56 52 15	1 26	1 25	7	56 53 33	0 15 16	57 8 49
o — 23.	29.49	57	56 59 32	6	16 1	57 15 39	1 28	1 27	7	57 16 59	0 8 10	57 8 49
h — 24.	29.71	57	57 23 0	6	16 1	57 39 7	1 29	1 28	7	57 40 28	0 31 35	57 8 53
h — 28.	29.98	54	58 56 38	6	16 2	59 12 46	1 35	1 36	8	59 14 14	2 5 16	57 8 58
h Oct. 18.	29.48	50	66 32 51	7	16 7	66 49 5	2 11	2 10	8	66 51 7	9 42 7	57 9 0
o — 23.	29.41	48	68 19 49	7	16 9	68 36 5	2 23	2 23	8	68 38 20	11 29 27	57 8 53
o Dec. 16.	29.59	35	80 8 21	9	16 19	80 24 49	5 20	5 33	9	80 30 13	23 21 16	57 8 57
o — 21.	29.93	35	80 14 48	9	16 19	80 31 16	5 23	5 39	9	80 36 46	23 27 58	57 8 48
h — 22.	29.85	32	80 14 55	9	16 19	80 31 23	5 23	5 40	9	80 36 54	23 27 54	57 9 0
1788.												
h Sept. 8.	30.04	62	51 30 10	5	15 56	51 46 11	1 11	1 10	7	51 47 14	5 21 41	57 8 55

Latitude, 57 9 0.9
or 57 9 1

HAVING the following observations of fixed stars reduced, I have also sent them.

Observed Distances of Fixed Stars from the Zenith of the Observatory.

1786.	Bar.	Th.	Name of Stars.	Zen. dist.	Error Quad.	Mean Ref.	True Ref.	T. Zen. dist.	M. Declina.	Ab.	Nut.	App: Decl.	Latitude.
24 June 22.	29.82	55	Arcturus	36° 50' 14"	+	3" 0' 43"	0' 43"	36° 51' 0"	20° 18' 2"	+	6"	20° 18' 1"	57° 9' 1"
9 Sept. 1.	29.49	55	α Lyra.	18 32 37	1	0 19	0 19	18 32 57	38 35 45	16	+	8 36 9	57 9 6
8 Oct. 25.	30.37	44	Altair.	48 48 31	5	1 5	1 8	48 49 44	8 19 20	9	0	8 19 11	57 8 55
24 — 26.	30.42	44	—	48 48 29	5	1 5	1 8	48 49 42	8 19 20	9	0	8 19 11	57 8 53
7 Dec. 2.	29.50	37	Pole Star.	31 1 0	1	0 34	0 35	31 1 37	88 10 8	+	17	7 88 10 32	57 8 55
7 — 24.	29.93	24	γ Cas. arc Excess.	87 35 12	—	1 0 2	0 2	87 35 13	59 33 53	17	3	59 34 13	57 9 0
— —	—	—	β Cassiopeia.	88 1 23	1	0 2	0 2	88 1 24	59 7 12	16	5	59 7 33	57 8 57
8 — 27.	28.95	36	α Cassiopeia.	1 46 47	1	0 2	0 2	1 46 48	55 51 39	16	3	55 52 19	57 9 7
Latitude,													57 8 59½

THE declinations of the above stars were taken from M. DE LA LANDE's catalogue of the declinations of 350 stars, adapted to the beginning of the year 1790.

I SHALL conclude by observing, that the differences in the above latitudes are to be attributed to the error of observation, to the inaccuracy of the division of the quadrant, and to the uncertainty of the refraction, especially at low altitudes. If the refraction at 45° be assumed a little greater than that by Dr BRADLEY, the results will agree much better. It must also be observed, that the smoke of the town will increase the refraction.

I am,

Dear Sir,

Your obedient servant,

ANDREW MACKAY.

L E T T E R II*.

DEAR SIR,

Aberdeen, 20th September 1796.

HAVING finished the comparison of a considerable number of observations, made in this place, in order to determine its longitude, with corresponding observations made at Greenwich, I now send you the several results. The observations used for this purpose are, eclipses of the satellites of Jupiter, particularly those of the first and second satellites, solar and lunar eclipses, occultations, &c. These observations were made with one of DOLLOND's three and a half foot achromatic telescopes, and powers of about seventy, and one hundred and fifteen, were applied to the telescope, according to circumstances. The observations at Greenwich were made with one of DOLLOND's forty-six inch achromatic telescopes.

As the results, deduced from a comparison of the corresponding observations of the first and second satellites of Jupiter, are
much

* COMMUNICATED 7th November 1796.

much more to be depended on than those inferred from the observations of the third and fourth satellites, I have therefore rejected the observations of the two last. This I was inclined to do, partly from the disagreement of the results of the corresponding observations of these two satellites, and partly upon account of the smallness of the number of corresponding observations. Indeed, as these two satellites take a considerable time to immerge into, and emerge out of the shadow of Jupiter, and as the state of the atmosphere, at the times of observation at Greenwich and Aberdeen, may be very different, and as powers will be applied to the telescopes according to the state of the atmosphere, it is not wonderful, that there should be a considerable difference between the results of the actual observations; and hence the propriety of rejecting the observations of the third and fourth satellite will be obvious; especially in the case when the corresponding observations are very few, and the number of immersions unequal to that of the emersions. The longitude of this place, as deduced from the comparison of the actual observations of the first and second satellites of Jupiter, made here and at Greenwich, seems to be less than the truth, or, at least, less than what I had been accustomed to state it; but the near agreement of the final results of each of these satellites is really surprizing.

Of all the other observations which I have compared, I have sent you only two, as being the most to be relied on, namely, a solar eclipse, and an occultation, besides a lunar eclipse, which I had published formerly in my *Treatise on the Longitude*, and which is not far from being a mean between the results of the other observations. I had, indeed, only one other occultation, of which the observations at Greenwich and Aberdeen were complete, namely, that of β of 15th October 1790; my other observations of that kind, being either incomplete, or having no corresponding observations at Greenwich.

I HAVE made the calculations for the longitude from the solar eclipse and occultation, first, on the supposition that the figure of the earth is a perfect sphere; and, secondly, upon Sir ISAAC NEWTON's spheroidal hypothesis, in which the equatorial diameter is to the axis of the earth as 230 : 229; between which limits, it is probable, is the real figure of the earth. In the rules which I gave, in my *Treatise on the Longitude*, for making the calculations by means of the nonagesimal, I followed the method of calculating the parallaxes in latitude and longitude, which had been given by M. DE LA LANDE, in the first and second editions of his *Astronomie*: But, in the present calculations, I have used the method which was given for the first time by M. MAYER, in the second volume of the *Memoirs of Gottingen*, published in the year 1753; and, again, in his *Solar and Lunar Tables*, printed at London, by order of the Board of Longitude, in the year 1770. This same method has also been employed by Messrs LEXELL, DE LA GRANGE, and DE LAMBRE: And it has been adopted by M. DE LA LANDE, in the second volume of the third edition of his *Astronomie*, printed at Paris in the year 1792*. It may also be proper to mention, that I have followed M. DU SEJOUR, and M. DE LA LANDE, in using an irradiation of $3\frac{1}{2}''$ for the sun's semidiameter, and an inflexion of the same quantity for the moon's. See SEJOUR's *Traité Analytique*, &c. vol. I. p. 253 and 264; and DE LA LANDE's *Astronomie*, third edition, vol. II. p. 445.

As some perhaps will be inclined to repeat the calculations for the longitude, from the observations of the solar eclipse and occultation, it will therefore be necessary to inform

* In making these calculations, I was led to discover an error in the method I had given in my *Treatise on the Longitude*, for finding the longitude of a place by an occultation. That error, and several others, will be corrected in a new edition of that work.

inform them what tables I used for that purpose. The logarithmic tables were TAYLOR's, CALLET's, and SHERWIN's. From TAYLOR's *Tables* were taken the logarithm sines and tangents of arches, and conversely. The logarithm sines, and conversely of the parallaxes, were taken from CALLET's *Tables*: and the logarithms of numbers from SHERWIN's. By this means much time was saved in these extensive calculations. The natural versed sines were taken from my *Treatise on the Longitude*; and the augmentation of the moon's semidiameter was taken from M. DE LAMBRE's *Tables*, for finding it by means of the altitude and longitude of the nonagesimal, which, therefore, saved the trouble of calculating the altitude of the moon. The sun's parallax was taken from the *Connoissance des Temps*; and, as I had not the *Nautical Almanac* for the year 1788, the elements for the solar eclipse were taken from the *Connoissance des Temps* for that year; but the elements for the occultation were taken from the *Nautical Almanac* for 1787.

DETER-

DETERMINATION of the Longitude of the Observatory at
Aberdeen, by the Eclipses of the First and Second Sa-
tellites of Jupiter.

FIRST SATELLITE.

Year, Month, and Day.	Apparent Time of Observation at				Longitude in Time, by	
	Greenwich.		Aberdeen		Immer.	Emer.
	Immer.	Emer.	Immer.	Emer.		
	h. ' "	h. ' "	h. ' "	h. ' "		
♂ Jan. 3. 1786.		8 15 54		8 7 39		8 15
♂ Sept. 18. —	16 7 37		15 58 57		8 40	
♀ — 20. —	10 36 38		10 27 40		8 58	
♂ Dec. 30. —		9 45 20		9 37 43		7 37
♀ Jan. 31. 1787.		6 15 32		6 7 8		8 24
♀ Feb. 23. —		6 31 57		6 23 46		8 11
♂ Dec. 14. 1788.	8 34 55		8 27 12		7 43	
♂ Mar. 1. 1791.	9 14 8		9 5 23		8 45	
♂ Apr. 9. —		10 4 48		9 56 49		7 59
					126	26
				Longitude,	8 31 5	8 5.2
						8 31.5
				Mean,	-	8 18.3

SECOND SATELLITE.

	h. ' "	h. ' "	h. ' "	h. ' "	' " "	' " "
♂ Nov. 7. 1786.	9 10 27		9 1 23		9 4	
♂ Mar. 8. 1787.		7 48 3		7 40 14		7 49
♀ Dec. 21. —		5 14 30		5 6 27		8 3
♂ Nov. 9. 1789.	14 23 42		14 15 24		8 18	
					17 22	15 52
					Longitude, 8 41	7 56
						8 41
					Mean, 16 37	
					Mean by 1st Sat. 8 18.5	
						8 18.3
					Mean Longitude, 8 18.4	

DETER-

DETERMINATION of the Longitude of the Observatory at Aberdeen, from the Apparent Times of Observation of the Beginning and End of the Solar Eclipse of 3d June 1788: Observed at Greenwich and Aberdeen.

	h. ' "		h. ' "
Apparent time of begin. at Greenwich,	19 24 46 $\frac{1}{2}$	at Aberdeen,	19 33 19
of end.	21 1 24		20 57 37
Interval,	1 36 37 $\frac{1}{2}$		1 24 18

COMPUTATION of the Apparent Time of Conjunction at Greenwich, on the Spherical Hypothesis.

	s. ° ' "		s. ° ' "
Moon's true longitude at beginning,	2 13 19 37	at ending,	2 14 18 59
Computed parallax in longitude,	+ 30 11		+ 22 32
Moon's apparent longitude nearly,	2 13 49 48		2 14 41 31
Moon's equat. hor. parallax,	60 33.0		60 34.9
Sun's horizontal parallax,	8.7		8.7
Difference of parallax of sun and moon,	60 24.3		60 26.2
h. ' "			
App. time beg.	19 24 46 $\frac{1}{2}$		
Sun's R. A.	4 51 30 $\frac{1}{2}$		
R. A. meridian,	0 16 17		
Arch,	6 16 17	v. fine,	0.0297853
Latitude,	51 28 40	co-fine,	9.7943612
Ob. ecliptic,	23 28 3	fine,	9.6001327
Sum,	74 56 43	co. v. s. 034322	
		265631	5.4242792
Alt. nonag.	45 34 9	v. fine,	299953
		fine,	9.8537566
Vol. IV.			Long.

DETERMINATION of the LATITUDE

Long. nonag.	29 32 39			secant,	0.0604925
Moon's app. long.	73 49 48				
Diff.	44 17 9	fine,	9.8440037		
Alt. nonag.	45 34 9	fine,	9.8537566	co-fine,	9.8451277
Diff. hor. par.	60 24.3	fine,	8.2447766	fine,	8.2447766
Par. in long.	30 7.0	fine,	7.9425369	P. in lat. 42' 17".1,	8.0899043
App. time end.	21 1 24				
Sun's R. A.	4 51 47				
R. A. mer.	1 53 11				
	6				
Arch,	7 53 11	v. fine,	0.1685046	co-secant,	0.0552648
Latitude and obl.	74 56 43	co. v. s. 0.34322	9.3944939		0.2056388
			365593		9.5629985
Alt. nonag.	53 7 26	v. fine,	399915	fine,	9.9030547
Long. nonag.	46 43 15			secant,	0.1639583
Moon's app. long.	74 41 31				
Diff. Δ Non.	27 58 16	fine,	9.6711972		
Alt. nonag.	46 43 15	fine,	9.9030547	co-fine,	9.7782140
Diff. hor. par.	60 26.2	fine,	8.2450042	fine,	8.2450042
Par. in long.	22 34.2	fine,	7.8172561	P. in lat. 36' 16".0,	8.0232182
Moon's true mot. in long. in ob. int.	-	59 22.0		True mot. in lat.	5 30.3
Sun's true mot. in long.	-	3 51.0		Par. in lat. at end.	36 16.0
Moon's true rel. mot. in long.	-	55 31.0		Sum,	41 46.3
Par. in long. at beginning,	-	30 7.0		Par. in lat. at begin.	42 17.1
at ending,	-	+ 22 34.2		App. mot. in lat.	30.8
App. rel. mot. in longitude,	-	47 58.2			

Apparent

Apparent mot. in lat.	30.8	1.4885507	
Apparent mot. in long.	47 58.2	3.4591210	3.4591210
Apparent inclination 36' 47",	tang.	8.0294297	co-fine, 9.9999751
Moon's apparent mot. in relative orbit, 2878."3			3.4591459

Moon's semidiameter at begin.	16 30	at end.	16 30	Sun's semid.	15 48.5
Augmentation,	+ 9.0		+ 12.5	Irradiation,	3.5
Inflexion,	- 3.5		- 3.5	Cor. semid.	15 45.0
Corrected semidiameter,	16 35.5		16 39.0		
Sun's semidiameter,	15 45.0		15 45.0		
Sum,	32 20.5		32 24.0		

Sum of semid. at end.	1944.0			ar. co. log.	6.7113037
at begin.	1940.5	ar. co. log.	6.7120864		3.2879136
App. mot. in rel. orbit,	2878.3	ar. co. log.	6.5408639		
Sum,	6762.8				
Half,	3381.4	log.	3.5290965		
Remainder,	1437.4	log.	3.1575776		
			19.9396244		
	21 6 59	co-fine,	9.9698122		

Central angle at begin.	42 13 58			fine,	9.8274625
-------------------------	----------	--	--	-------	-----------

Central angle at end.	42 8 21			fine,	9.8266798
-----------------------	---------	--	--	-------	-----------

Central angle at begin.	42 13 58	at end.	42 8 21		
App. inclination,	36 47	App. in.	36 47		

Arch,	42 50 45	co-s.	9.8652142	Arch,	41 31 34	co-s.	9.8742810
Sum of semidiameters,	32 20.5	3.2879136	sum fem.	32 24	3.2886963		
	23 42.8	3.1531278		24 15.4	3.1629773		
					Par.		

DETERMINATION of the LATITUDE

Par. in long. at begin.	° ' "	30 7.0	at end.	22 34.2
Sum,	53 49.8	3.5091756	Diff.	1 41.2
Rel. mot. in long.	55 31	ar. co. 6.4774254		6.4774254
Observed interval,	1 36 37½	3.7632408		3.7632408
Int. bet. beg. and conj.	1 33 41.4	3.7498418	bet. end & con.	2 56.1
App. time of beg.	19 24 46.5		Apparent time of ending,	21 1 24.
App. time of conj.	20 58 27.9			20 58 27.9

COMPUTATION of the Apparent Time of Conjunction at Aberdeen.

App. time of begin.	h. ' "	19 33 19	App. time of end.	h. ' "	20 49 29
Estimated longitude,	+	8 36		+	8 36
Reduced time,	-	19 41 55			20 58 5
Moon's true long.	-	2 13 30 8	at end.		2 14 16 57
Par. in long. nearly,	+	24 49		+	19 45
Moon's app. long. nearly,		2 13 54 57			2 14 36 42
Moon's hor. parallax,		60 33.3			60 34.8
Sun's		8.7			8.7
Diff. hor. par.	-	60 24.6			60 26.1
App. time of begin.	-	19 33 19	App. time of end.		20 49 29
Sun's right ascension,	-	4 51 34			4 51 47
Right ascen. meridian,		0 24 53			1 41 16

Now, with the right ascension of the meridian at the beginning, increased by six hours, or $6^h 24' 53''$, the latitude of the place of observation $57^\circ 9' 0''$, and the obliquity of the ecliptic $23^\circ 28' 3''$, the altitude of the nonagesimal is $41^\circ 39' 6''$, and its longitude $35^\circ 46' 6''$; hence the moon's apparent distance from the nonagesimal is $38^\circ 8' 51''$, with which the altitude of the

the nonagesimal, and difference of the horizontal parallaxes of the sun and moon, the parallax in longitude is $24' 47''.9$, and in latitude $45' 8''.2$.

AGAIN, with $7^h 41' 16''$, the sum of the right ascension of the meridian and six hours, the latitude and obliquity of the ecliptic, the altitude of the nonagesimal, is $47^\circ 17' 40''$, and longitude $48^\circ 8' 35''$; the apparent distance of the moon from the nonagesimal is, therefore, $26^\circ 28' 7''$; from whence, the altitude of the nonagesimal, and the difference of the horizontal parallaxes of the sun and moon, the parallax in longitude is $19' 47''.6$, and parallax in latitude $40' 59''.3$.

THE true motion of the moon in longitude is $46' 48''.2$, and that of the sun $3' 2''.1$; hence the moon's relative motion in longitude is $43' 46''.1$; from which, subtracting the difference of the parallaxes in longitude $5' 0''.3$, the remainder $38' 45''.8$ is the apparent relative motion of the moon in longitude.

THE true motion of the moon in latitude, in the observed interval, is $4' 20''.4$; from which, subtracting $4' 8''.9$, the difference of the parallaxes in latitude, the remainder is the moon's apparent motion in latitude.

Now, with the apparent motions of the moon in longitude and latitude, the apparent inclination is found to be $17' 0''$, and the apparent motion of the moon in its relative orbit is $2325''.8$.

WITH the altitude and longitude of the moon at the beginning and end of the eclipse, the augmentation of the moon's semidiameter at the beginning is $9''.0$, and at the end $11''.4$; hence the moon's semidiameter, corrected by the augmentation and inflexion, is $16' 35''.5$ at the beginning of the eclipse, and $16' 37''.9$ at the end; and the sum of the semidiameters of the sun and moon, at those times, are $32' 20''.5$, and $32' 22''.9$ respectively; with which, and the moon's apparent motion in relative orbit, the central angle at the beginning of the eclipse is

53°

$53^{\circ} 15' 20''$, and at the end $53^{\circ} 9' 39''$; hence arch first is $53^{\circ} 32' 20''$, and arch second $52^{\circ} 52' 39''$.

WITH these arches, and the sum of the semidiameters of the sun and moon at the beginning and end of the eclipse, arches third and fourth will be found equal to $19' 13''.2$ and $19' 32''.6$ respectively. Now, the sum of arch third, and the parallax in longitude at the beginning is $44' 1''.1$, and the difference between arch fourth, and the parallax in longitude at the end, is $15''.0$. Now, with this sum and difference, the moon's true relative motion in longitude, and the observed interval, the difference between the beginning of the eclipse and the conjunction is $1^h 16' 36''.1$, and between the end and the conjunction $26''.1$. Hence the apparent time of conjunction, inferred from the beginning, is $20^h 49' 55''.1$, and from the end it is also $20^h 49' 55''.1$. But the apparent time of conjunction at Greenwich is $20^h 58' 27''.9$; hence the longitude of Aberdeen in time is $8' 32''.8$ west.

COMPUTATION of the Apparent Time of Conjunction, on the Spheroidal Hypothesis, at Greenwich.

	h. ' "		h. ' "
Appt. time of beginning,	19 24 46 $\frac{1}{2}$	Appt. time of ending,	21 1 24
Sun's right ascension,	4 51 30 $\frac{1}{2}$		4 51 47
	<hr/>		<hr/>
Right ascen. meridian,	0 16 17		1 53 11
Moon's true long.	2 13 19 37		2 14 18 59
Ecl. par. in long.	+ 30 10		22 52
	<hr/>		<hr/>
Estimated app. long.	2 13 49 47		2 14 41 50
Moon's hor. par.	60 33.0		60 34.9
Reduction,	— 9.6		— 9.6
	<hr/>		<hr/>
Reduced hor. par.	60 23.4		60 25.3
			Sun's

And LONGITUDE of ABERDEEN.

151

Sun's hor. par.	° ' "	8.7		° ' "	8.7
Difference,	-	60 14.7		60 16.6	
Altitude nonag.	-	45 46 19		53 20 35	
Long. nonag.	-	29 21 19		46 35 16	
Par. in long.	-	30 14.6		22 46.9	
Par. in lat.	-	42 1.2		35 19.1	
Moon's true rel. mot. in lon.		55 31.0	Moon's true mot. in lat.		5 30.3
Diff. par. in longitude,		7 27.7	Diff. par. in latitude,		6 2.1
3's app. rel. mot. in long.		48 3.3	App. mot. in lat.		31.8
App. inclination,	-	37 55	App. mot. in rel. orbit,		48 3.5
Moon's semidiameter,		16 30.0			16 30.0
Augmentation,	-	+ 9.0			+ 12.5
Inflexion,	-	- 3.5			- 3.5
Corrected semidiameter,		16 35.5			16 39.0
Sun's semid. — Irrad,		15 45.0			15 45.0
Sum,	-	32 20.5			32 24.0
Central angle,	-	42 7 6			42 1 30
App. inclination,		37 55			37 55
Arch first,	-	42 45 1	Arch second,		41 23 35
Arch third,		23 44.9	Arch fourth,		24 18.4
Par. in long. at beginning,		30 14.6	At end.		22 46.9
Sum,	-	53 59.5	Difference,		1 31.5
Hence interval between	h. ' "		Interval between the end and	h. ' "	
the beg. and conj.		1 33 58.3	conjunction,		0 2 39.2
App. time of begin.		19 24 46.5	App. time of ending,		21 1 24.0
App. time of conj.		20 58 44.8			20 58 44.8

At Aberdeen.

App. time of beginning,	h. ' "	19 33 19	App. time of end.	h. ' "	20 49 29
Sun's right ascension,	-	4 51 34			4 51 47
Right ascen. of meridian,		0 24 53			1 41 16
					Moon's

DETERMINATION of the LATITUDE

	s. ° ' "	s. ° ' "
Moon's true longitude,	2 13 30 8	2 14 16 57
Estimate par. in longitude, +	24 55	+ 19 54
Estimated apparent long.	2 13 55 3	2 14 36 51
Moon's hor. parallax,	60 33.3	60 34.8
Reduction, -	- 11.1	- 11.1
Reduced parallax, -	60 22.2	60 23.7
Sun's hor. par.	- 8.7	8.7
Difference, -	60 13.5	60 15.0
Altitude nonag. -	41 59 6	47 29 32
Longitude nonag. -	35 33 53	47 59 26
Par. in longitude, -	24 55.4	19 54.2
Par. in latitude, -	44 52.2	40 42.6
Moon's true rel. mot. in long.	43 46.1	Moon's true mot. in lat. 4 20.4
Diff. par. in longitude, -	5 1.2	Diff. par. in latitude, 4 9.6
App. mot. in longitude, -	38 44.9	App. mot. in latitude, 10.8
App. inclination, -	15 58	App. mot. in rel. orbit, 38 44.9
Moon's semidiameter,	16 30.0	16 30.0
Augmentation, -	+ 9.2	+ 11.6
Inflexion, -	- 3.5	- 3.5
Corrected semidiameter,	16 35.7	16 38.1
Sun's semid., — Irrad.	15 45.0	15 45.0
Sum, -	32 20.7	32 23.1
Central angle, -	53 16 36	53 10 55
App. inclination, -	15 58	15 58
Arch first, -	53 32 34	Arch second, 54 57
Arch third, -	19 13.2	Arch fourth, 19 31.7
Par. in longitude, -	24 55.4	19 54.2
Sum, -	44 8.6	Difference, 22.5

Hence

	h. ' "		h. ' "
Hence the interval between the beg. and conj. is	1 16 49.2	Interval between the end and conjunction is	39.2
App. time of beginning,	19 33 19.	App. time of ending,	20 49 19.
App. time of conj.	20 50 8.2		20 50 8.2
App. time of conj. at Green.	20 58 44.8		
Longitude in time,	8 36.6		

DETERMINATION of the Longitude of the late Observatory at
Aberdeen, from the Apparent Times of Observation of the
Immerfion and Emerfion of π II: Observed at Greenwich
and Aberdeen, 9 November 26. 1787.

	h. ' "		h. ' "
App. time of immer. at Gr.	11 22 51.7	At Aberdeen,	11 18 8
Emer.	12 31 45.		12 23 12
Observed interval,	1 8 53.3		1 5 4

COMPUTATION of the Apparent Time of Conjunction in the
Spherical Hypothefis, at Greenwich.

	h. ' "		h. ' "
App. time of immer.	11 22 51.7	App. time of emer.	12 31 45
Sun's right afcenfion,	16 10 56.7		16 11 8
Right afcen. of meridian,	3 33 48.4		4 42 53
Moon's true longitude,	2 29 50 23		3 0 33 32
Eftimate par. in long.	+ 23 9		+ 13 3
Eft. apparent longitude,	3 0 13 32		3 0 33 32
Moon's true latitude,	0 20 3.5		0 24 1.8
Eftimate par. in latitude,	+ 32 9.5		+ 30 5.2
Eft. apparent latitude,	0 52 14. S.		0 54 7. S.
Vol. IV.	T		Horizontal

DETERMINATION of the LATITUDE

Horizontal parallax,	° ' "	61 11.3		° ' "	61 10.6
Alt. nonag.	-	58 49 53			61 4 57
Long nonag.	-	64 18 46			76 24 45
Par. in longitude,	-	22 52.7			13 17.0
Par. in latitude,	-	32 22.7			30 23.6
Moon's true rel. mot. in long.	43 8.4		Moon's true mot. in latitude,	3 58.3	
Diff. par. in longitude,	9 35.7		Diff. par. in latitude,	1 59.1	
<hr/>					
Moon's appt. mot. in long.	33 32.7		Appt. mot in latitude,	1 59.2	
Appt. inclination,	3 23 22		Appt. mot. in orbit,	33 36.2	
Moon's semidiameter,	16 40.1			16 39.9	
Augmentation,	+ 13.7			+ 15.2	
Inflexion,	- 3.5			- 3.5	
<hr/>					
Corrected semidiameter,	16 50.3			16 51.6	
Central angle at immer.	4 18 24		At emerion,	4 18 4	
Apparent inclination,	3 23 22			3 23 22	
<hr/>					
Arch first,	7 41 46		Arch second,	0 54 42	
Arch third,	16 41.2		Arch fourth,	16 51.5	
Parallax in longitude,	22 52.7			13 17.0	
<hr/>					
Sum,	39 33.9		Difference,	3 34.5	
Hence interval between			Interval between the emerion		
immer. and conj.	1 3 10.8		and conjunction,	5 42.5	
Appt. time of immer.	11 22 51.7		Appt. time of emer.	12 31 45.	
<hr/>					
Appt. time of conjunct.	12 26 2.5			12 26 2.5	

AT Aberdeen.

Appt. time of immer.	h. ' "	11 18 8	Appt. time of emerion,	h. ' "	12 23 15
Sun's right ascension,		16 10 57.4			16 11 9
<hr/>					
Right ascen. of meridian,	3 29 5.4			4 34 21	
	s. ° ' "			s. ° ' "	
Moon's true longitude,	2 29 52 48.8			3 0 33 33.6	
<hr/>					
E.R.					

And LONGITUDE of ABERDEEN.

155

Err. par. in longitude,	0 12 45.2	Err. par. in longitude,	0 12 38.4
Err. app't. longitude,	3 0 13 34	Err. app't. longitude,	3 0 46 12,
Moon's true latitude,	20 16.9	Moon's true latitude,	24 2.0
Err. par. in latitude,	37 6.1	Err. par. in latitude,	35 18.0
Approx. app't. latitude,	57 23.0 S.	Approx. app't. latitude,	59 20.0 S.
Horizontal parallax,	61 11.3	Horizontal parallax,	61 10.6
Alt. nonag.	53 8 59.	Alt. nonag.	55 17 2
Longitude nonag.	65 29 36	Longitude nonag.	76 3 32
Par. in longitude,	20 29.1	Par. in longitude,	12 46.2
Par. in latitude,	37 24.9	Par. in latitude,	35 40.4
Moon's true mot. in long.	40 44.8	Moon's true mot. in latitude,	3 45.1
Diff. of par. in longitude,	7 42.9	Diff. of par. in latitude,	1 44.5
Moon's app't. mot. in long.	33 1.9	App't. mot. in latitude,	2 0.6
App't. inclination,	3 28 56	App't. mot. in orbit,	33 5.5
Moon's semidiameter,	16 40.1	Moon's semidiameter,	16 39.9
Augmentation,	+ 12.9	Augmentation,	24.1
Inflexion,	- 3.5	Inflexion,	3.5
Moon's corrected semid.	16 49.5	Moon's corrected semid.	16 50.5
Central angle,	10 35 40	Central angle,	10 35 20
App't. inclination,	3 28 56	App't. inclination,	3 28 56
Arch first,	7 16 44	Arch second,	14 3 58
Arch third,	16 41.7	Arch fourth,	16 20.7
Par. in longitude,	20 29.1	Par. in longitude,	12 46.2
Sum,	37 10.8	Difference,	3 34.0
Hence the interval be-	h. ' "	Interval between the emer. and	h. ' "
tween im. and conj.	0 59 22.3	conjunction,	0 5 41.7
App't. time of immer.	11 18 8	App't. time of emerion,	12 23 12
App't. time of conj.	12 17 39.3	App't. time of conj.	12 17 39.3
At Greenwich,	12 26 2.5	At Greenwich,	12 26 2.5
Longitude in time,	8 32.2	Longitude in time,	8 32.2

COMPUTATION of the Apparent Times of Conjunction in the Spheroidal Hypothesis, at Greenwich.

Moon's true long. at im.	2 29 50 23	At emerfion,	3 0 33 32
Eft. parallax in longitude,	+ 22 57		13 19 00
Appt. longitude nearly,	3 0 13 20		3 0 46 51
Moon's true latitude,	20 35		24 1.8
Eft. parallax in latitude,	32 5 5		30 5.2
Appt. latitude nearly,	52 9.		54 7.
Horizontal parallax,	61 11.3		61 10.6
Reduction,	9.8		9.8
Reduced parallax,	61 1.5		61 0.8
Latitude of Greenwich,	51 28 40		
Reduction,	14 37		
Reduced latitude,	51 14 3		
Alt. nonagefimal,	59 3 56		61 19 24
Longitude nonagefimal,	64 14 2		76 22 15
Par. in longitude,	22 56.2		13 19.3
Par. in latitude,	32 4.8		30 5.5
Moon's true mot. in long.	43 8.4	Moon's true mot. in latitude,	3 58.3
Diff. of par. in long.	9 36.9	Diff. par. in latitude,	1 59.3
Appt. mot. in longitude,	33 31.5	Appt. mot. in latitude,	1 59.0
Appt. inclination,	3 23 8	Appt. mot. in orbit,	33 35.0
Central angle at immer.	4 44 16	At emerfion,	4 43 54
Arch first,	8 7 24	Arch fecond,	1 20 46
Arch third,	16 40.2	Arch fourth,	16 51.3
Parallax in longitude,	22 56.2		13 19.3
Sum,	39 36.4	Difference,	3 32.0
Hence the interval between h. ' "		Interval between the emer.	
the immer. and conj.	1 3 14.8	and conjunction,	5 38.5
Appt. time of immer.	11 22 51.7	Appt. time of emer.	12 31 45.
Appt. time of conj.	12 26 6.5		12 26 6.5

AT

And LONGITUDE of ABERDEEN.

157

At Aberdeen.

	s. ° ' "	At emer.	s. ° ' "
Moon's true long. at immer.	2 29 52.49		3 0 33.34
Eft. par. in long.	+ 20 45		12 34
Appr. longitude nearly,	3 0 13.34		3 0 46.8
Moon's true latitude,	20 17		24 2
Estimated par. in latitude,	37 6		35 18
Appr. latitude nearly,	57 23		59 20
Moon's horizontal parallax,	61 11.3		61 10.6
Reduction,	- 11.3		- 11.3
Reduced parallax,	- 61 0.0		60 59.3
Latitude Aberdeen,	- 57 9 0		
Reduction,	- 13 41		
Reduced latitude,	- 56 55 19		0 1 "
Altitude nonag.	- 53 21 52		55 30 30
Longitude nonag.	- 65 24 42		76 0 36
Par. in longitude,	- 20 32.8		12 48.8
Par. in latitude,	- 37 7.2		35 22.1
M's true mot. in long.	- 40 44.8	True mot. in latitude,	3 45.1
Diff. of par. in longitude,	7 44.5	Diff. parallax in latitude,	1 45.1
Appr. mot. in longitude,	33 0.3	Appr. mot. in latitude,	2 0.0
Appr. inclination,	- 3 28 4	Mot. in appr. orbit,	33 3.9
Central angle at immer.	10 51 14	At emer.	10 50 35
Arch first	- 7 23 10	Arch second,	14 18 39
Arch third,	- 16 41.1	Arch fourth,	16 19.2
Par. in longitude,	- 20 32.8		12 48.3
Sum,	- 37 13.9	Difference,	3 30.9
Interval between the immer. h. ' "		Interval between the emer. h. ' "	
and conj.	- 0 59 27.2	and conj.	0 5 36.8
Appr. time of immer,	11 18 8	Appr. time of emer,	12 23 12
Appr. time of conj.	12 17 35.2		12 17 35.2
Appr. time of conj. at Gr.	12 26 6.5		

Longitude

Longitude in time, -	8 31.3	Long. on spherical hyp. by occult.	8 32.2
Long. by solar eclipse, -	8 36.6	by eclipse, 8 32.8	
Mean,	8 33.9	Mean,	8 32.5

If we suppose, with Messrs DU SEJOUR and LA LANDE, that the difference between the equatorial and polar diameters is $\frac{1}{100}$ of the equatorial diameter, in that case the longitude will be 8' 33'.6.

DETERMINATION of the Longitude of the Observatory at Aberdeen, by Observations of the Lunar Eclipse of 10th September 1783, made at Aberdeen and at Chislehurst in Kent, 19' in Time East of the Royal Observatory at Greenwich.

	Names of Spots.	Apparent Time of Observation at		Diff. of Mer.
		Aberdeen.	Chislehurst.	
		h. ' "	h. ' "	h. ' "
INGRESS.	Aristarchus,	9 42 42.5	9 50 55	8 12.5
	Kepler,	9 44 9.6	9 52 20	8 10.4
	Copernicus,	9 54 8.7	10 2 24	8 15.3
	Manilius covered,	10 7 35.8	10 15 30	7 54.2
	Tycho covered,	10 8 57.8	10 17 5	8 19.2
	Menelaus covered,	10 10 51.9	10 19 10	8 18.1
	Dionysius covered,	10 13 46.9	10 21 38	7 51.1
	Plinius covered,	10 14 55.9	10 22 40	7 44.1
	Mare Crisum E. end,	10 25 51.0	10 34 34	8 43.0
	W. end,	10 30 53.0	10 39 45	8 52.0
	Total darkness,	10 36 39.0	10 46 34	9 55.0
		Sum,	-	254.9
		Mean,	-	8 23.17
EGRESS.	Aristarchus,	12 24 4.3	12 33 52	9 47.7
	Kepler,	12 27 5.3	12 37 26	10 20.7
	Copernicus,	12 35 34.4	12 45 52	10 18.6
	Plato E. end,	12 38 32.4	12 47 22	8 49.6
	Tycho E. end,	12 40 4.4	12 48 30	8 25.6
	W. end,	12 41 5.4	12 49 58	8 53.6
	Menelaus,	12 53 0.6	13 1 46	8 39.4
	Dionysius,	12 54 45.6	13 3 18	8 32.4
	Plinius,	12 56 48.6	13 5 40	8 51.4
	Mare Crisum E. end,	13 7 10.7	13 16 35	9 24.3
	W. end,	13 12 20.8	13 26 53	8 32.2
		Sum,	-	95.5
		Mean per egress,	-	9 8.68
		Mean per ingress,	-	8 23.17
				17 31.85
		Diff. mer. Aber. and Chislehurst in time nearly,	8 45.92	
		Longitude of Chislehurst in time E.	19.	
		Longitude of Aberdeen nearly,	-	8 26.92
		Change of equation of time in 8' 26".9		.12
		Longitude of Aberdeen,	-	8 26.3 W.

DETER-

DETERMINATION of the Longitude of the Observatory at Aberdeen by a Chronometer, constructed by Mr ARNOLD of London*.

THE chronometer was set to mean solar time at Greenwich, 16th June 1788, and lost $7''.5$ in eleven days. It was sent to Aberdeen by sea; and being compared with the Observatory clock, 15th July, it was found to be $7' 26''.6$ fast, and was losing $6''.4$ daily: It is hence probable that the motion of the ship had altered its rate. Now, supposing this alteration to have commenced when the ship left London, which was on the 8th of July, its error at that time, for the meridian of Greenwich, would therefore be $15''.0$; from this time, till 15th July, it lost $44''.8$, ($= 6''.4 \times 7$), its rate being supposed uniform. Hence its error, for the meridian of Greenwich, 15th July at noon, was $-59''.8$. But its error, for the meridian of the Observatory at Aberdeen, at the same time, was $+7' 26''.6$. Hence the longitude of Aberdeen, in time, is $8' 26''.4$ west.

THIS last method of ascertaining the longitude of Aberdeen, although it agrees very well with the former, yet it is not to be so much depended on, as there are some suppositions introduced which may be objected to.

FROM a comparison of the preceding results, it may be presumed, that the longitude of this place, in time, is probably not less than $8' 18''$, as deduced from the observations of the eclipses of the first and second satellites of Jupiter, nor greater than $8' 36''$, as inferred from the solar eclipse of 3d June 1788. The difference between these limits is only $18''$ in time; which in this latitude does not amount to two miles and an half. Upon account of the near agreement of the results of the solar eclipse and occultation, as well as from other observations, I am led to believe

* SEE Theory and Practice of finding the Longitude, &c. vol. I. p. 208.

believe that $8' 32''$ or $2^{\circ} 8'$ is not far from the exact longitude of this place. Hence the latitude of the Girdlenefs is $57^{\circ} 8'$, and longitude $2^{\circ} 6' W.$ and the latitude of Greignefs $57^{\circ} 7' 20''$, and longitude $2^{\circ} 6' W.$ also.

THE latitude and longitude of Aberdeen, as determined above, differ considerably from the same as given in most books of geography and navigation, where indeed they are usually stated with great inaccuracy. Mr DOWNIE, to whom, at his request, I communicated the result of my observations, has, in his *New Pilot*, placed Aberdeen nearly as above, and of course has laid down the adjacent coast, with much more precision than had been formerly done. This was in 1793; I then supposed the longitude $2^{\circ} 9' W.$ which is $1'$ greater than the above determination.

believe that $8^{\circ} 32'$ or $2^{\circ} 8'$ is not far from the exact longitude of this place. Hence the latitude of the Quadrant is $57^{\circ} 8'$ and longitude $2^{\circ} 6' W$ and the latitude of Greenwich $53^{\circ} 7'$ and longitude $2^{\circ} 6' W$ also.

The latitude and longitude of Aberdeen, as determined above, differ considerably from the same as given in most books of geography and navigation where indeed they are usually stated with great inaccuracy. Mr. Dowie, to whom, at the request, I communicated the result of my observations, has, in his view, placed Aberdeen nearly as above, and of course has laid down the adjacent coast with much more precision than had been formerly done. This was in 1793; I then supposed the longitude $2^{\circ} 9' W$, which is 3' greater, and the above determined

VI. *An ACCOUNT of certain MOTIONS which Small Lighted WICKS acquire, when swimming in a BASON of OIL; together with OBSERVATIONS upon the PHENOMENA tending to explain the PRINCIPLES upon which such MOTIONS depend: Communicated in a Letter from PATRICK WILSON, F. R. S. EDIN. and Professor of Practical Astronomy in the University of Glasgow, to JOHN PLATFAIR, F. R. S. EDIN. and Professor of Mathematics in the University of Edinburgh.*

[Read May 5. 1795.]

DEAR SIR, *Glasgow College, April 28. 1795.*

I Now sit down to give you some account of the little hydrostatical lamp, which I so briefly mentioned to you in a former letter. As I am far from being sure whether what I have to offer upon this subject may be entitled to the notice of the Edinburgh Royal Society, so I will refer this point to your determination, after you have had leisure to consider the contents.

THE phenomena, treated of in the sequel, were quite new to me a few months ago, and, so far as I know, have not hitherto been attended to, or described by any body else. What I have called the *Hydrostatical Lamp*, consists of a small circular patch of common writing paper, about three eighths of an inch in diameter, having about a quarter of an inch of soft cotton thread

standing up through a puncture in the middle to serve as a wick; and the phenomena, in question, are certain motions which such minikin lamps acquire, when lighted and made to swim in very pure salad oil.

A SHALLOW glass basin, with sides rising nearly perpendicular, or a common glass salver, will conveniently contain the oil for these experiments. As soon as the lamp is lighted, it will immediately sail briskly forward, in some direction, till it meets the side of the vessel, and afterwards will take a circular course, always bearing up to the sides, and so will perform many revolutions.

SOMETIMES the circulation is from right to left, and sometimes in the contrary direction, according as that point of the paper base, which in the direct sailing kept always foremost, turns away from the side of the glass a little to the right or to the left hand of that which comes to be the point of contact. This turning away, of what may be called the LEADING POINT of the base, is distinctly observable by a partial rotation of the lamp round the wick as an axis, as soon as it arrives at the side of the vessel. Sometimes, though rarely, the leading point itself attaches to the side, and forms the *vinculum*, in consequence of the well known corpuscular attraction between the elevation of oil around the base, and that belonging to the sides of the glass; and when the *vinculum* so corresponds to the leading point, the lamp will be found to stand still, without any tendency to circulate.

WHEN the little wick has any sensible excentricity upon the circular paper base, the lamp will sail so as to make that part of the base which lies nearest to the wick the *stern*; and if the base of the lamp be clipped of an oval form, and the wick placed in the longer axis excentrical, that end of the base, nearest the wick, will also keep hindmost, when the lamp sails across the salver. In the same manner, if the base be

an equilateral triangle, having its wick in the perpendicular which bisects any of the sides, either the vertex or side will become the *stern*, and keep hindmost; according as the wick is placed nearest the one or the other. Lamps, so constructed, are found also to circulate upon their arrival at the side of the vessel, when the leading point turns away from the glass, as it commonly happens.

WHATEVER be the cause of the sailing of the lamp directly foreward, the perpetual circulation, after it arrives at the side, seems to proceed from the force, which formerly impelled it, still acting in the same manner, but in a direction inclined to that of the corpuscular attraction, which forms the vinculum; and it is evident, that this inclination will be greater or less, according as the leading point is more or less averted from the glass. When it so happens that the leading point and vinculum coincide, it should seem that both forces, just now mentioned, must urge the lamp in a direction perpendicular to the side of the glass; in which case it must stand still, agreeable to observation.

THE next thing which I had occasion to take notice of, when the lamp sailed in a direct course, was, a seemingly very active repulsion between its stern and the oil at the surface contiguous to it. This became manifest, when very fine charcoal dust was lightly scattered around the lamp. As it then proceeded in its course, it marked out a spreading or diverging *wake* behind it, entirely clear of all dust, in consequence of the particles being chased backwards, and laterally with a motion much more than merely relative.

DESIROUS of learning how this dispersion of the dust would take place when the lamp was stationary, I constructed one of a fine wafer, and with an excentric wick, consisting of a soft cotton thread doubled; and to prevent the wafer or base from catching fire, I coated its upper surface with gold leaf. When
this

this was made to rest immoveably upon the oil, the dust retired in all directions, so as to leave the space adjacent to the wafer quite free from every particle. But here it was observable, that this dispersion of the dust, by the seeming repulsion of the base of the lamp, was much more rapid at that side which lay nearest to the wick than at any other part, and least of all sensible at the side diametrically opposite.

THE circumstances last mentioned, seem sufficiently to account both for the progressive motion of the lamp, and for the general law of this motion, formerly described. For, regarding this dispersion of the dust, as yet, only in a general way, and as the effect of some repulsion between the base and the oil contiguous to it, the facts above mentioned plainly indicate, that, in all cases, this repulsion is strongest at that part of the base nearest the wick or flame: and as action and reaction are equal and contrary, the lamp must therefore be impelled, in the direction of a line drawn through the wick, towards that part of the base most remote from it, and where the reaction is the least.

BUT in order to obtain a still more competent knowledge of the physical cause of these motions, it seemed now necessary to inquire more particularly into this apparent repulsion between the base of the lamp and the surrounding oil, as indicated by the dispersion of the dust, in the manner above described: and here the following considerations presented themselves.

THE oil in the basin, when of an uniform temperature, has all its parts in a state of equilibrium and of rest. When the lamp is lighted, it is evident we have a very active cause introduced, tending to destroy that equilibrium. This cause is the flame, which broods over a small portion of the oil, and is separated from it only by the intervention of a piece of paper or a wafer. The oil, in such circumstances, in consequence of being violently heated, must suddenly increase in volume, and must now, on account of the decrease of its specific gravity, be pressed

pressed upwards by a force sufficient to raise part of it above the general level. But this heated portion of oil, in its endeavour thus to rise up, will meet with a resistance equal to the weight of the incumbent lamp, which will determine it, in seeking a vent, to slide out from under the base in a *thin superficial stream*; and it seems to follow, with equal certainty, that this constant stream will flow most readily and most copiously towards that side of the base of the lamp where the resistance is least, or where it has the shortest way to press forward; that is, from under the wick or flame, to the edge of the base which is the nearest, according to what we have seen to be agreeable to the phenomena. But, from the laws of motion, it is certain, that the reaction of this stream of rarified oil, thus issuing most rapidly and most copiously from a particular side of the base, must impel the lamp in the contrary direction, and make it sail in the manner we have seen. It may further be remarked, that the heated oil, so retreating from the flame, and endeavouring to rise somewhat above the general level, in consequence of its diminished specific gravity, may more or less lift up that side of the base nearest the wick, and aid the reaction of the recoiling stream, by making the lamp sail in the opposite direction, as it were *down-bill*.

THAT the rarified oil under the base has really a constant tendency to rise above the general level, seems undeniable, from the following facts, namely, that after any of the lamps has burned a little while, and has got its base soaked with the oil, as soon as the flame is blown out the lamp sinks to the bottom; and even a lamp, with its base made of a thin lamina of talck, sails very well till the flame is extinguished, and then it immediately sinks.

AGREEABLE to the explanation which has now been attempted, I found, that when a *topical heat* was applied to the surface of the oil, by bringing the point of a poker, dully red hot, nearly

ly into contact, there was soon produced a superficial stream or efflux from the iron in all directions, which cleared the face of the oil from the charcoal dust, in a wider and a wider circle, till at last the whole particles were crowded together at the confines of the bafon.

WHEN the oil in this experiment was shallow, having gold leaf beat into very minute parts mixed with it, an opposite stream was observed below, setting in towards the poker in all directions, and then rising upwards. But this general tendency of all the parts of the fluid of moving in quest of an equilibrium, is illustrated in a very entertaining manner as follows: Into a tea-cup or punch-glass, nearly filled with pure water, pour a desert spoonful of very clean salad oil, with minute particles of gold leaf in it. If the water be cold, the oil, when poured on at the centre, leisurely and continuedly, will rest upon the surface in the form of a lens, and remain insulated or equidistant from the sides of the vessel. A little lamp, when put upon this lens of oil, and lighted, will sail and circulate as larger ones do in the bafon. If it be now made to stand still, it is very amusing to observe the minute particles of the gold perpetually thrown out briskly at the stern in the superficial current, whilst the particles in the fund of the lens creep in all directions towards the lamp, and at last rise up under the base towards the flame, as the great centre of attraction, till they are caught by the retreating superficial stream, in which they rapidly trend off to some distance, when again they sink to renew the circulation.

WHEN a patch of paper, or a wafer, or such light body, swims upon the oil in the bafon, the point of a hot iron held near to it makes it flit its place, and move away by a seeming repulsion; but, in reality, by the heat generating a superficial stream, flowing from the iron in all directions.

AGAIN,

AGAIN, if upon oil of turpentine, æther, alcohol, or any of the inflammable fluids possessing much tenuity, you throw a wafer much heated, it will immediately glide away, and continue in motion till it cools; when the stream, which issued from some part of it most copiously, ceases. Double rum, melted tallow, bees wax, and rosin, also afford the same continued efflux at the surface, upon a topical application of heat, and the same phenomena as the oil does, when little lamps are made to swim in them. It is somewhat remarkable, however, that though the inflammable fluids all agree in this, yet the topical application of heat, at the surface of water, does not produce similar effects.

FOR if the point of a poker nearly red hot be held very close to the surface of water in a bason, the particles of the charcoal dust do not at all glide away as they do in the case of oil, but seem to acquire only a slow irregular circular motion, which in time spreads wider, whilst the floating motes or particles of dust keep nearly their relative places; and the same thing happens, though the point of the iron touches the water, so as to make it simmer.

I DO not well know how to account for this, unless it may be a consequence of the known much less expansibility of water by heat, compared to that of the inflammable fluids, and which may be so inconsiderable as not to destroy the equilibrium, so far as to produce an efflux from the lighter and expanded fluid immediately under the heated body. Possibly, too, the parts of the water, as soon as heated, may transmit the surplus temperature to the contiguous colder water much more rapidly than the inflammable fluids do in like circumstances, and thereby resist the high temperature, necessary to that degree of expansion, which would disturb the equilibrium, and produce an efflux; not to mention that the maximum of this temperature can never, at any rate, exceed 212° , the boiling point of water.

THAT the equilibrium, however, amongst the parts of water, is disturbed by the local application of heat, though in a much smaller degree than what obtains among the inflammable fluids, appears from an experiment I was led to make with a small thin cup swimming on water, and so contrived as to carry and feed with oil a wick, placed a little way down from the lip in the inside, so as to be on a level with the water. The consequence of this construction was, that the cup moved upon the water very slowly, but always with the flame evidently sternmost. The same cup, when taken from the water, and put into a basin of strong rum, sailed a great deal faster, and according to the same usual law.

I AM much afraid, that by this time I have wearied you by such a detail of minute facts and circumstances, and by those frequent repetitions which every new subject more or less requires. And I ever remain,

Dear Sir,

Your most obedient faithful servant,

PAT. WILSON.

P. S. SHOULD you be inclined to repeat any of the experiments, the following directions and miscellaneous observations may be attended to: The thread I made use of for the wicks was of that soft kind commonly employed in the flowering of muslin. After making the puncture in the base, you put through a bit of the thread, which clip short off below, and with a pin force in the burr gently round the thread, to give the base a proper hold of it. Then clip away the superfluous thread above, leaving the wick about a quarter of an inch long; and so the lamp is completed. Set it then upon the oil, by taking hold of the wick, that the paper base may not be bent or distorted by handling

handling it; and, after the wick is touched with a drop of oil, it is ready for being lighted. For this purpose, a bit of pack thread, which has been steeped in oil, is a cleanly and convenient match, and sheds no impurities on the oil, as a candle or wax taper would do.

WHEN you want the lamps to circulate, the oil must be very pure, and brought into full contact with the sides of the glass. The oil, and the bason or salver, should all be allowed to come to the same temperature, between 55° and 60° of Fahrenheit. For if any part of the brim be much hotter than the rest, the lamp, on arriving there, will leave the side, by the current issuing from the heated part forcing it away.

SOMETIMES the lamp, when sailing, veers a little into a different direction, by the base altering or warping by the scorching heat of the flame, which determines the stream to flow out most copiously at a different part of the base.

IN the melted grease which lies round the wick of a common candle when lighted, there are sometimes observed atoms, which have been left by the snuffers, moving to and from the flame continually. These motions have been conceived by some as occasioned by attractions and repulsions, in consequence of an electrical quality imputed to the flame. It should seem, however, that they depend merely upon opposite currents at the surface, and immediately below the surface of the melted grease, according to the principle above explained.

VII. *An ACCOUNT of a SINGULAR HALO of the MOON. Communicated in a Letter from WILLIAM HALL, Esq; of White-Hall, F. R. S. EDIN. to Sir JAMES HALL, Bart. F. R. S. EDIN.*

[Read May 2. 1796.]

DEAR SIR JAMES, *Whitehall, near Berwick, April 2. 1796.*

I SEND under cover the representation of a very singular Halo of the Moon, (See Pl. V.), seen here on the night of the 18th of February last, about 10 o'clock, and this I have hitherto delayed, in order, if possible, to gain farther information in the neighbourhood concerning it.

DURING the short continuance of the small halo, which did not exceed 10 minutes after I got notice of it, I could not lay my hands on any other instrument to take the angles, but a Sisson's theodolite, which, unluckily, having been constructed so as not to admit of a vertical angle so great as the moon's altitude then was, I laid it aside, not recollecting that it might have measured several of the smaller angles. But I observed fundry marks, from which I took the angles as exactly as I could next day.

THE moon was about S. W. and her altitude nearly 54° , which of consequence was also the altitude of the limb of the greater halo, where it was highest, and where it passed through
the

the moon ; the altitude of its opposite limb was 14° ; so that its diameter subtended an angle of no less than a hundred and twelve degrees.

THE diameter of the small halo, which appeared to be a perfect circle, with the moon in its centre, I found, after repeated trials, was under 12° , and more than 8° ; but as the different diameters of the large halo were not measured, it cannot positively be affirmed that it was an exact circle ; on the contrary, its limb did not seem to intersect the small circle quite so much at right angles, as the circular arch delineated in the plan. It may therefore have been somewhat elliptical.

THE small circle was remarkably bright, particularly at *West Reelson*, about five miles to the northward, the only other place where the halo was observed, and where it was thought to send forth flame. The small halo also continued there much longer than here, where some thin fleecy clouds soon put an end to it, but the large halo continued with us near an hour.

THE weather about this time was, for the season, remarkably mild, particularly on the day of the halo. The sky was pretty clear all that day, and also in the evening ; but at the time of the halo there was a small degree of haziness, particularly towards the north, which did not however prevent the moon from shining with brightness ; and the stars were even visible within the circle of the small halo : there was little or no wind.

THE circles or belts of both halos are represented in the plan, nearly of their apparent breadth, or perhaps a little broader ; the light of both was whitish, and considerably bright, without colour ; that of the large circle was the paler of the two, particularly where it passed through the small circle : to the northward it was somewhat obscure.

By means of the angles taken as above, after having ascertained, on a vertical circle of the heavens, the situations of the
moon,

moon, of the small halo, and of the north-eastern limb of the large halo, whose south-western limb passed through the moon, the whole was projected on the horizontal plane, as in the figure already referred to. The moon, a little more than half, is placed in the centre of the smaller halo; and both halos are represented in their true situations, relatively to the horizon, and in the circular shape which they appeared to have, though they ought perhaps to have been somewhat foreshortened, and thrown into an elliptic form.

THIS halo, as you will see by the above description, appears to be of the kind called by the learned a *Corona*; and as it somewhat resembles the famous one of the sun, observed at Rome in the year 1629, and described by SCHEINER*, it deserves the more attention, especially as the great halo, on the present occasion, having its south-western limb elevated to the height of 54° , and its north-eastern depressed to within 14° of the horizon, was in an oblique position, not easily reconciled with the theory of HUYGENS, which seems to require that such circles should be equally elevated above the horizon all round. It also shews, that SCHEINER's original plan of the halo at Rome, which represented it as oblique, may have been right, and that HUYGENS's correction, which makes it parallel to the horizon, was probably an erroneous conjecture.

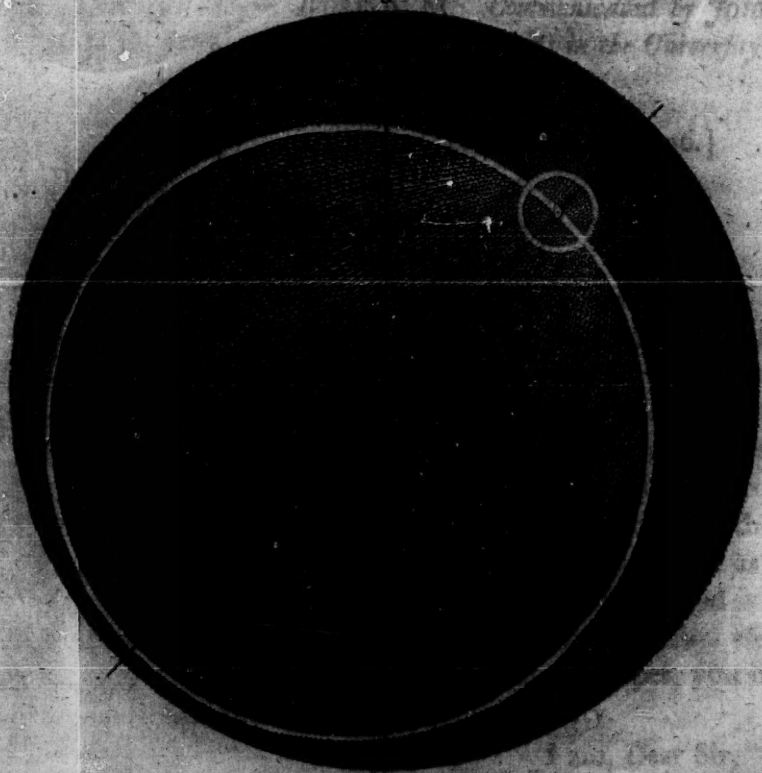
I am,

Dear Sir JAMES,

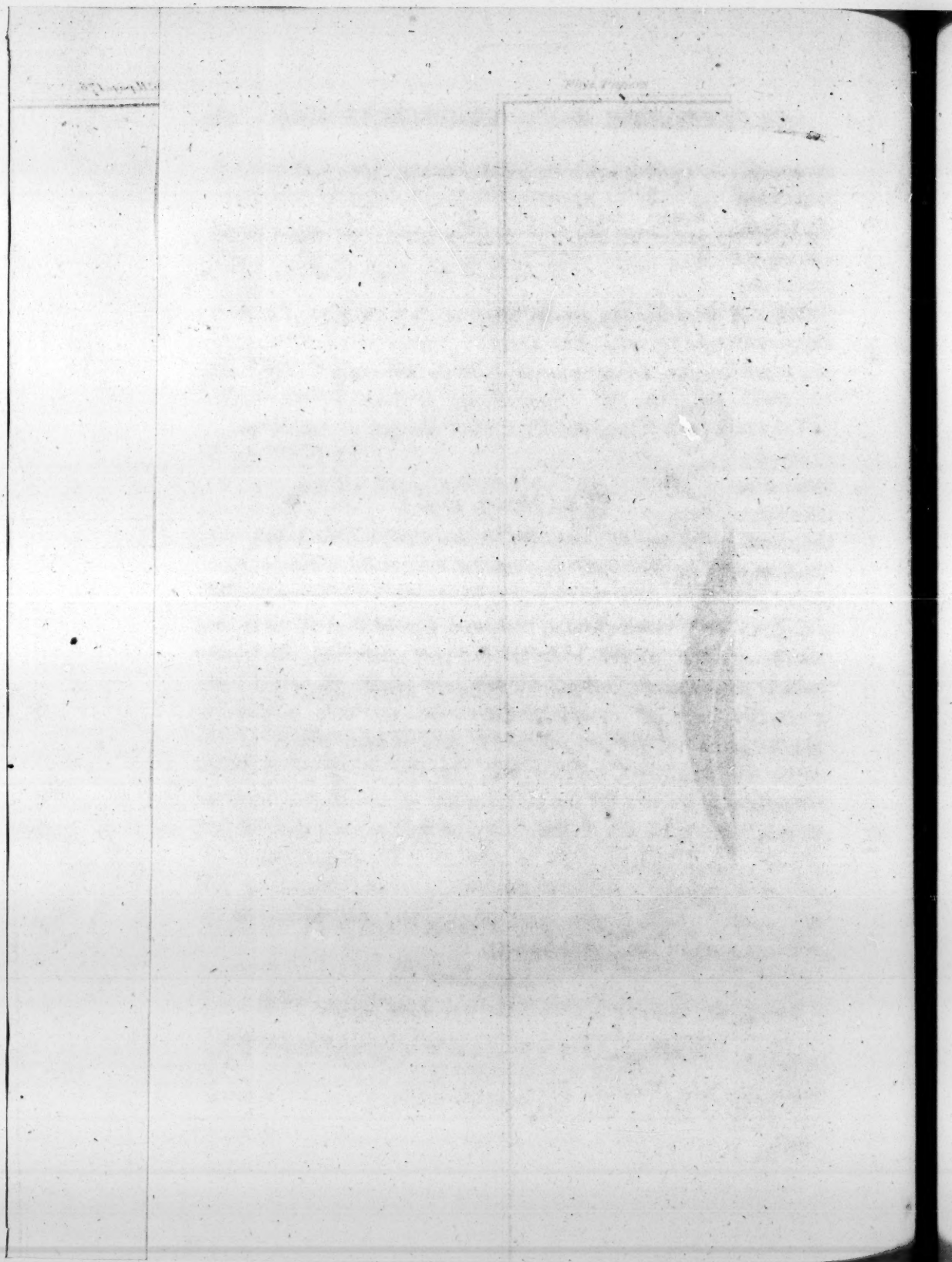
Your humble servant,

WILL. HALL.

* SMITH's Optics, vol. I; § 534.



*Figure of a Halo about the Moon seen in
Berwick shire on the 18th of Feb: 1796.*



VIII. *A NEW SERIES for the RECTIFICATION of the ELLIPSIS ; together with some OBSERVATIONS on the EVOLUTION of the FORMULA $(a^2 + b^2 - 2ab \cos \phi)^n$. By JAMES IVORY, A. M. Communicated by JOHN PLAYFAIR, Professor of Mathematics in the University of Edinburgh.*

[Read Nov. 7. 1796.]

DEAR SIR,

HAVING, as you know, bestowed a good deal of time and attention on the study of that part of physical astronomy which relates to the mutual disturbances of the planets, I have, naturally, been led to consider the various methods of resolving the formula $(a^2 + b^2 - 2ab \cos \phi)^n$ into infinite series of the form $A + B \cos \phi + C \cos 2\phi + \&c$. In the course of these investigations, a series for the rectification of the ellipsis occurred to me, remarkable for its simplicity, as well as its rapid convergency. As I believe it to be new, I send it you, inclosed, together with some remarks on the evolution of the formula just mentioned, which, if you think proper, you may submit to the consideration of the Royal Society.

I am, Dear Sir,

Your's, &c.

DOUGLASTOWN, near Forfar, }
20th October 1796. }

JAMES IVORY.

To Mr John Playfair, Pro-
fessor of Mathematics, &c.

178 RECTIFICATION of the ELLIPSIS, &c.

LET ϵ denote the excentricity of an ellipse, of which the semi-transverse axis is unity, and π the length of the semicircle, radius being unity: Then,

$$\text{if we put } e = \frac{1 - \sqrt{1 - \epsilon^2}}{1 + \sqrt{1 - \epsilon^2}},$$

half the periphery of the ellipsis will be

$$= \frac{\pi}{1+e} \left(1 + \frac{1^2}{2^2} e^2 + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} e^4 + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} e^6 + \frac{1^2 \cdot 1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2 \cdot 8^2} e^8 + \&c. \right),$$

 the coefficients being the squares of the coefficients of the radical $\sqrt{1 - \epsilon^2}$.

THE common series is,

$$\pi \times \left(1 - \frac{1}{2} \cdot \frac{1}{2} \epsilon^2 - \frac{1 \cdot 1}{2 \cdot 4} \cdot \frac{1 \cdot 3}{2 \cdot 4} \epsilon^4 - \frac{1 \cdot 1 \cdot 3}{2 \cdot 4 \cdot 6} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \epsilon^6 - \&c. \right).$$

THE first of these series converges faster than the other on two accounts: first, because the coefficients decrease more rapidly; and, next, because ϵ is very small in comparison of e , even when ϵ is great: Thus, if ϵ be $\frac{4}{5}$, e will be $\frac{1}{4}$, and $e^2 = \frac{1}{16}$.

IN order to point out the way in which the preceding series was discovered, let us suppose $(a^2 + b^2 - 2ab \cos \phi)^n = A + B \cos \phi + C \cos 2\phi + \&c.$; and to determine the coefficients, A, B, C, &c. let us, with M. DE LA GRANGE, consider the quantity $(a^2 + b^2 - 2ab \cos \phi)$ as the product of the two imaginary expressions $(a - bc \phi \sqrt{-1})$, and $(a - bc - \phi \sqrt{-1})$, where c denotes the number whose hyperbolic logarithm is unity. Then, by expanding the powers $(a - bc \phi \sqrt{-1})^n$, and $(a - bc - \phi \sqrt{-1})^n$ into the series $a^n \left(1 - n \cdot \frac{bc}{a} \phi \sqrt{-1} + \frac{n \cdot n-1}{2} bc^2 \phi^2 \sqrt{-1}^2 - \frac{n \cdot n-1 \cdot n-2}{6} bc^3 \phi^3 \sqrt{-1}^3 + \&c. \right)$

and

and $a^n \left(1 - \alpha \frac{b}{a} c - \phi \sqrt{-1} + \beta c - 2\phi \sqrt{-1} + \gamma c - 3\phi \sqrt{-1} + \&c. \right)$

we have $\alpha = n, \beta = \frac{n \cdot n - 1}{1 \cdot 2}, \gamma = \frac{n \cdot n - 1 \cdot n - 2}{1 \cdot 2 \cdot 3} \&c.$

THEN multiplying these two series together, and putting $2 \cos m\phi$ for its imaginary value $c^{+m\phi\sqrt{-1}} + c^{-m\phi\sqrt{-1}}$, we shall find, on equating the terms,

$$A = a^{2n} \times \left(1 + \alpha^2 \frac{b^2}{a^2} + \beta^2 \frac{b^4}{a^4} + \gamma^2 \frac{b^6}{a^6} + \&c. \right),$$

$$B = -2a^{2n} \times \left(\alpha \cdot \frac{b}{a} + \alpha\beta \cdot \frac{b^3}{a^3} + \beta\gamma \cdot \frac{b^5}{a^5} + \&c. \right),$$

and so on.

OF the several series for A, B, C, &c. the first deserves particular attention, on account of the simplicity of the law of its terms. It deserves the more attention, too, that the whole fluent $\int \phi (a^2 + b^2 - 2ab \cos \phi)^n$, generated while ϕ from 0 becomes π , half the circumference of the circle, is $= A + \pi$: all the other terms of the fluent then vanishing.

SUPPOSE now, in an ellipsis, the semi-transverse $= 1$, the eccentricity $= e$, and ϕ an arch of the circumscribing circle, reckoned from the extremity of the transverse: then the fluxion of the correspondent arch of the ellipsis, cut off by the same ordinate, will be $= \phi \sqrt{1 - e^2} \cos^2 \phi$.

In this expression, I write $\frac{1}{2} + \frac{1}{2} \cos 2\phi$, for $\cos^2 \phi$: and put the result, $\phi \sqrt{1 - \frac{e^2}{2}} - \frac{e^2}{2} \cos 2\phi = \phi \sqrt{a^2 + b^2 - 2ab \cos 2\phi}$, a and b being indeterminate quantities.

To determine a and b , we have $a^2 + b^2 = 1 - \frac{e^2}{2}$, and $2ab = \frac{e^2}{2}$:

whence $a + b = 1$, and $a - b = \sqrt{1 - e^2}$: so that $a = \frac{1 + \sqrt{1 - e^2}}{2}$

and $b = \frac{1 - \sqrt{1 - e^2}}{2}$.

180 RECTIFICATION of the ELLIPSIS, &c.

I THUS obtain $\dot{\phi} \sqrt{1 - e^2 \cos^2 \phi} = \dot{\phi} \sqrt{a^2 + b^2 - 2ab \cos 2\phi}$: and, taking the whole fluent, while ϕ from 0 becomes $= \pi$, it is manifest, from what has been premised, that the semiperiphery of the ellipsis is =

$$\pi \times a \times \left(1 + \frac{1}{2} e^2 + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} e^4 + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} e^6 + \&c. \right),$$

or putting $\frac{b}{a} = e = \frac{1 - \sqrt{1 - e^2}}{1 + \sqrt{1 - e^2}}$, and $a = \frac{a}{a+b} = \frac{1}{1 + \frac{b}{a}} = \frac{1}{1 + e}$,

the semiperiphery of the ellipsis $= \frac{\pi}{1 + e} \times$

$$\left(1 + \frac{1}{2} e^2 + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} e^4 + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} e^6 + \&c. \right)$$

IN this series, as was before observed, e is a small fraction even when e is very considerable, and the coefficients are more simple in the law of progression, and converge faster, (especially in the first terms), than in the common series.

IF we suppose the ellipsis to be infinitely flattened, in which case $e = 1$, and $e = 1$, and the semiperiphery $= 2$, this series gives $2 = \frac{\pi}{2} \times \left(1 + \frac{1}{2} + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} + \&c. \right)$, and so

$$\frac{4}{\pi} = 1 + \frac{1}{2} + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} + \frac{1^2 \cdot 1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2 \cdot 8^2} + \&c.$$

BUT, we may remark, that as we have here obtained the sum of the squares of the coefficients of the binomial when the exponent is $\frac{1}{2}$; so, from the same source, we may determine the sum of the squares of the coefficients corresponding to any other exponent, at least by a fluent.

FOR taking the whole fluent when $\phi = \pi$, we have

$$\int (a^2 + b^2 - 2ab \cos \phi)^n \dot{\phi} = a^{2n} \pi \left(1 + \alpha^2 \frac{b^2}{a^2} + \beta^2 \frac{b^4}{a^4} + \gamma^2 \frac{b^6}{a^6} + \&c. \right)$$

and so when $a = 1$, and $b = 1$,

$$\int \frac{(a^2 + b^2 - 2ab \cos \phi)^n}{\pi} \dot{\phi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$$

Now,

Now, when $a = 1$, and $b = 1$, $\int \phi(a^2 + b^2 - 2ab \cos \phi)^n = 2^n \times \int \phi(\sin \frac{\phi}{2})^{2n}$, because $2(\sin \frac{\phi}{2})^2 = 1 - \cos \phi$: we thus obtain

$$\frac{2^{2n} \times \int \phi(\sin \frac{\phi}{2})^{2n}}{\pi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$$

the whole fluent to be taken when $\phi = \pi$, or $\frac{\phi}{2} = \frac{\pi}{2}$.

If we put $x = \sin \frac{\phi}{2}$, we shall have

$$\frac{2^{2n} \times \int \frac{x^{2n} dx}{\sqrt{1-x^2}}}{\frac{1}{2}\pi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c,$$

the whole fluent to be taken when $x = 1$; and in this formula n is any number fractional or integral, positive or negative; and α, β, γ , &c. the coefficients of the binomial raised to a power of which the exponent is n .

WHEN n is a whole positive number,

$$\frac{\int \frac{x^{2n} dx}{\sqrt{1-x^2}}}{\frac{1}{2}\pi} = \frac{1 \cdot 3 \cdot 5 \dots (2n-1)}{2 \cdot 4 \cdot 6 \dots 2n} \frac{\pi}{2}, \text{ in the case when } x = 1:$$

$$\text{And so, } 2^{2n} \times \frac{1 \cdot 3 \cdot 5 \dots (2n-1)}{2 \cdot 4 \cdot 6 \dots 2n} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$$

Now, $2^{2n} \times \frac{1 \cdot 3 \cdot 5 \dots (2n-1)}{2 \cdot 4 \cdot 6 \dots 2n}$ is no other than the coefficient of the middle term of a binomial, raised to the power expressed by $2n$: Hence we have a very curious property of those numbers: viz. that the sum of the squares of the coefficients of a binomial, the exponent being n , is equal to the coefficient of the middle term of a binomial, of which the exponent is $2n$.

ANOTHER remark, which I have to offer on this subject, may be considered not only as curious, in an analytical point of view, but as, in some measure, accomplishing an object that has much engaged the attention of mathematicians.

In the computation of the planetary disturbances, it becomes necessary to evolve the fraction $(a^2 + b^2 - 2ab \cos \phi)^{-\frac{1}{2}}$ into a series.

series of this form, $A + B \cos \phi + C \cos 2\phi + \&c.$ The quantities a and b represent the distances of the disturbing planets from the sun; and when these bear so great a proportion to one another, (as in the case of Jupiter and Saturn, or Venus and the Earth), that the fraction $\frac{b}{a}$ is large, it becomes extremely difficult to compute the coefficients A , B , &c. by series, on account of the great number of terms that must be taken in. This matter not a little perplexed the first geometers who considered this subject, and they were obliged to approximate to the quantities sought by the method of quadratures, and by other artifices.

Two things are to be attended to with regard to the quantities A , B , C , &c. The first is, That it is not necessary to compute all of them separately by series, or by other methods: They form a recurring series; and the two first being so computed, all the rest may be derived from them. The second thing is, That the quantities A and B having been computed for any exponent n , the correspondent quantities are thence derived, by easy formulæ, for the exponents $n+1$, $n+2$; $n-1$, $n-2$; and in general for the exponent $n+m$, m being any integer number, positive or negative.

From these remarks, it follows, that the whole difficulty lies in the computation of the two first quantities, A and B ; and that we are not confined to a given exponent n , but may choose any one in the series, $n+1$, $n+2$, &c.; $n-1$, $n-2$, &c.; that will render the computation most easy and expeditious.

Thus, in order to compute the quantities A and B , for the exponent $-\frac{3}{2}$, M. DE LA GRANGE makes choice of the exponent $+\frac{1}{2}$, which, in the whole series of exponents $+\frac{3}{2}$, $+\frac{1}{2}$, $-\frac{1}{2}$, $-\frac{3}{2}$, &c. is the most favourable for computation, on account of the convergency of the coefficients of the series for A and B .

IN

IN considering these subjects, however, I have fallen upon a method of computing the quantities A and B for the exponent $-\frac{1}{2}$ by series that converge so fast, that, even taking the most unfavourable case that occurs in the theory of the planets, two or three terms give the values required with a sufficient degree of exactness. This is what I am now to communicate.

WE are then to consider the expression $(a^2 + b^2 - 2ab \cos \phi)^{-\frac{1}{2}}$
 $= \frac{1}{\sqrt{a^2 + b^2 - 2ab \cos \phi}}$: for the sake of simplicity in calculation,

I write $\frac{b}{a} = c$, throwing out a altogether; and I suppose

$$\frac{1}{\sqrt{1 + c^2 - 2c \cos \phi}} = A + B \cos \phi + C \cos 2\phi + \&c.$$

LET ψ be an angle, so related to ϕ , that $\sin(\psi - \phi) = c \sin \psi$:
 It is obvious, from this formula, that $\psi = \phi$ when $\sin \psi = 0$,
 that is, when ψ is equal to 0, or to π , 2π , &c.

WE have then, $\cos(\psi - \phi) = \sqrt{1 - c^2 \sin^2 \psi}$: and taking
 the fluxions, $\psi - \phi = \frac{c \cos \psi \times \dot{\psi}}{\cos(\psi - \phi)} = \frac{c \cos \psi \times \dot{\psi}}{\sqrt{1 - c^2 \sin^2 \psi}}$:

whence $\phi = \psi \times \frac{\sqrt{1 - c^2 \sin^2 \psi} - c \cos \psi}{\sqrt{1 - c^2 \sin^2 \psi}}$.

BUT $(\sqrt{1 - c^2 \sin^2 \psi} - c \cos \psi)^2 = 1 - c^2 \sin^2 \psi + c^2 \cos^2 \psi$
 $- 2c \cos \psi \sqrt{1 - c^2 \sin^2 \psi} = 1 + c^2 - 2c^2 \sin^2 \psi - 2c \cos \psi$
 $\sqrt{1 - c^2 \sin^2 \psi}$, (because $c^2 \cos^2 \psi = c^2 - c^2 \sin^2 \psi$) $= 1 + c^2$
 $- 2c \times (c \sin \psi \times \sin \psi + \cos \psi \sqrt{1 - c^2 \sin^2 \psi})$. Now, if we
 write for $c \sin \psi$ its equal, $\sin(\psi - \phi)$, and for $\sqrt{1 - c^2 \sin^2 \psi}$
 its equal, $\cos(\psi - \phi)$, we shall have $c \sin \psi \times \sin \psi + \cos \psi \times$
 $\sqrt{1 - c^2 \sin^2 \psi} = \sin(\psi - \phi) \times \sin \psi + \cos \psi \times \cos(\psi - \phi)$
 $= \cos \phi$: which being substituted, there comes out
 $(\sqrt{1 - c^2 \sin^2 \psi} - c \cos \psi)^2 = 1 + c^2 - 2c \cos \phi$.

OUR

OUR fluxional formula thus becomes $\dot{\phi} = \frac{\dot{\psi} \sqrt{1+c^2-2c \cos \phi}}{\sqrt{1-c^2 \sin^2 \psi}}$: whence $\frac{\dot{\phi}}{\sqrt{1+c^2-2c \cos \phi}} = \frac{\dot{\psi}}{\sqrt{1-c^2 \sin^2 \psi}}$.

I NEXT transform the quantity $\sqrt{1-c^2 \sin^2 \psi}$ as in the investigation for the elliptic series, and putting $c' = \frac{1-\sqrt{1-c^2}}{1+\sqrt{1-c^2}}$, I

find $\sqrt{1-c^2 \sin^2 \psi} = \frac{\sqrt{1+c'^2+2c' \cos 2\psi}}{1+c'}$, and so $\frac{\dot{\phi}}{\sqrt{1+c^2-2c \cos \phi}} = \frac{(1+c') \dot{\psi}}{\sqrt{1+c'^2+2c' \cos 2\psi}}$.

Now, taking the fluents when $\phi = \pi$, and $\psi = \pi$, we shall have $\int \frac{\dot{\phi}}{\sqrt{1+c^2-2c \cos \phi}} = A \times \pi$: And according to the method of M. DE LA GRANGE, $\int \frac{\dot{\psi}}{\sqrt{1+c'^2+2c' \cos 2\psi}} = \pi \times (1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c'^4 + \&c.)$: Hence $A = (1 + c') \times (1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c'^4 + \&c.)$. And in this value of A, c' will be a small fraction, even though c be large; and the series will therefore converge very fast.

BUT, taking the value of A directly in a series, we have $A = 1 + \frac{1^2}{2^2} c^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c^4 + \&c.$ And so $1 + \frac{1^2}{2^2} c^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c^4 + \&c. = (1 + c') \times (1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c'^4 + \&c.)$. Now, the two series being exactly alike, it is evident that we may transform the one, as we have transformed the other, and that, if we put $c'' = \frac{1-\sqrt{1-c'^2}}{1+\sqrt{1-c'^2}}$, we shall have $1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c'^4 = (1 + c'') \times (1 + \frac{1^2}{2^2} c''^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c''^4 + \&c.)$: whence $A = (1 + c') (1 + c'') (1 + \frac{1^2}{2^2} c''^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c''^4 + \&c.)$.

It

It is manifest we may proceed in this manner as far as we please, and that, if we put $c''' = \frac{1 - \sqrt{1 - c''^2}}{1 + \sqrt{1 - c''^2}}$; $c'''' = \frac{1 - \sqrt{1 - c'''^2}}{1 + \sqrt{1 - c'''^2}}$

and so on, we shall have the value of A in an infinite product, $A = (1 + c') \times (1 + c'') \times (1 + c''') (1 + c''') \times \&c.$, the quantities $c', c'', c''', c''', \&c.$ converging very rapidly.

NOTHING more seems to be wished for, with regard to the computation of the quantity A: since we can, by methods sufficiently simple, exhibit the value of it in series that shall converge as fast as we please. By a similar mode of reasoning, I find the series $1 - \frac{1}{2} \gamma^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} \gamma^4 - \frac{1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2} \gamma^6 + \&c.$ (which occurs in determining the time of a body's descent in the arch of a circle), $= (1 - c) \times (1 + \frac{1}{2} c^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c^4 + \frac{1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2} c^6 + \&c.)$ where $c = \frac{\sqrt{1 + \gamma^2} - 1}{\sqrt{1 + \gamma^2} + 1}$: so that the summation of this series also is accomplished by the method above.

I HAVE now only to explain the method of computing B. For this purpose I resume,

$$\frac{1}{\sqrt{1 + c^2 - 2c \cos \phi}} = A + B \cos \phi + C \cos 2\phi + \&c.$$

Multiply by $2 \cos \phi$, and there results

$$\frac{2 \cos \phi}{\sqrt{1 + c^2 - 2c \cos \phi}} = B + (2A + C) \cos \phi + \&c.$$

whence it is manifest that the whole fluent

$$\int \frac{2 \cos \phi \times \dot{\phi}}{\sqrt{1 + c^2 - 2c \cos \phi}}, \text{ when } \phi = \pi, \text{ is equal to } B \times \pi.$$

From the preceding investigation we have $\frac{\dot{\phi}}{\sqrt{1 + c^2 - 2c \cos \phi}} = \frac{\dot{\psi}}{\sqrt{1 - c^2 \sin^2 \psi}}$, and $\cos \phi = c \sin^2 \psi + \cos \psi \sqrt{1 - c^2 \sin^2 \psi}$,

whence $\frac{2\phi \cos \phi}{\sqrt{1+c^2-2c \cos \phi}} = \frac{2c \psi \sin^2 \psi}{\sqrt{1-c^2 \sin^2 \psi}} + 2\psi \cos \psi$. Again,

$$2 \sin^2 \psi = 1 - \cos 2\psi, \text{ and } \frac{1}{\sqrt{1-c^2 \sin^2 \psi}} = \frac{(1+c')}{\sqrt{1+c'^2+2c' \cos 2\psi}}$$

being $= \frac{1-\sqrt{1-c^2}}{1+\sqrt{1-c^2}}$: these substitutions being made, we get

$$\frac{2\phi \cos \phi}{\sqrt{1+c^2-2c \cos \phi}} = c \times \frac{(1+c')\psi}{\sqrt{1+c'^2+2c' \cos 2\psi}} - c \times \frac{(1+c')\psi \cos 2\psi}{\sqrt{1+c'^2+2c' \cos 2\psi}} + 2\psi \cos \psi.$$

$$\text{SUPPOSE NOW, } \frac{1}{\sqrt{1+c'^2+2c' \cos 2\psi}} = A' - B' \cos 2\psi + c' \cos 4\psi - \&c.$$

it is evident, from what goes before, that, taking the fluents of the above fluxions, when ϕ and $\psi = \pi$, we shall have $B \times \pi$

$$= c \times (1+c') \times (A' + \frac{B'}{2}) \times \pi, \text{ and so } B = c \times (1+c') \times (A' + \frac{B'}{2}).$$

THE values of A' and B' , in series according to the method of M. DE LA GRANGE, are

$$A' = 1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 \cdot 3^2}{2^2 \cdot 4^2} c'^4 + \frac{1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2} c'^6 + \&c.$$

$$\frac{1}{2} B' = (\frac{1}{2} c' + \frac{1}{2} \cdot \frac{1 \cdot 3}{2 \cdot 4} c'^3 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} c'^5 + \&c.).$$

which series converge very fast, on account of the smallness of c' in respect of c .

IF, however, it be required to find the value of B by series still more converging, we may easily do so: For it is manifest that B and B' are similar functions of c and c' : and that if we

$$\text{make } c'' = \frac{1-\sqrt{1-c'^2}}{1+\sqrt{1-c'^2}}, c''' = \frac{1-\sqrt{1-c''^2}}{1+\sqrt{1-c''^2}}, \text{ and so on, and put}$$

$A', A'', \&c.$; $B', B'', \&c.$ to denote the corresponding values of A' and B' ; we shall have

$$B = c \cdot (1 + c') \left(A + \frac{B'}{2} \right)$$

$$B' = c' \cdot (1 + c'') \left(A' + \frac{B''}{2} \right)$$

$$B'' = c'' \cdot (1 + c''') \left(A'' + \frac{B'''}{2} \right) \&c.:$$

Now, remarking that $A' = (1 + c'') A''$; $A'' = (1 + c''') A'''$, &c. we have the following values of B :

$$B = c \times \left(1 + \frac{c'}{2} \right) \cdot \left(1 + c' \right) \cdot \left(1 + c'' \right) A'' + \frac{c}{2} \cdot \frac{c'}{2} \cdot \left(1 + c'' \right) B''.$$

$$B = c \times \left(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \right) \cdot \left(1 + c' \right) \cdot \left(1 + c'' \right) A'' + \frac{c}{2} \cdot \frac{c'}{2} \cdot \frac{c''}{2} \cdot \left(1 + c' \right) \cdot \left(1 + c'' \right) B''.$$

And we may proceed in this manner to find the value of B in series that shall converge as fast as we please.

As the quantities $c', c'', c''', \&c.$ diminish very fast, the series A', A'', A''' will approach rapidly to unity, and B', B'', B''' will decrease rapidly to nothing: Hence we have ultimately,

$$B = c \times \left(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \cdot \frac{c'''}{2} + \&c. \right) \times \left(1 + c' \right) \cdot \left(1 + c'' \right) \cdot \left(1 + c''' \right) \&c.$$

or, since $A = (1 + c') (1 + c'') (1 + c''') \&c.:$

$$B = c \times \left(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \cdot \frac{c'''}{2} + \&c. \right) \times A.$$

We shall best see the degree of convergency of the quantities $c, c', c'', \&c.$ if we take the infinite series by which they are derived one from another. Now, if $y = \frac{1 - \sqrt{1 - x^2}}{1 + \sqrt{1 - x^2}}$, then also $y =$

$$\frac{x^2}{4} + \frac{x^4}{8} + \frac{5x^6}{64} + \frac{7x^8}{128} + \&c.: \text{whence it is obvious, that in the}$$

series of quantities $c, c', c'', \&c.$ the fourth part of the square of

any term is nearly equal to the following term, and the rapidity with which the series decreases is therefore very great.

THE method, then, that results from the preceding investigations for computing A and B, is shortly this :

Put $c' = \frac{1 - \sqrt{1 - c^2}}{1 + \sqrt{1 - c^2}}$: and compute

$$1 + \frac{1}{2} c'^2 + \frac{1 \cdot 3}{2 \cdot 4} c'^4 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} c'^6 + \&c. = M,$$

$$\text{and } \frac{1}{2} c' + \frac{1}{2} \cdot \frac{1 \cdot 3}{2 \cdot 4} c'^3 + \frac{1 \cdot 3}{2 \cdot 4} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} c'^5 + \&c. = N.$$

Then $A = (1 + c') \times M$, and

$$B = c \times (1 + c') \times (M + N).$$

THE series M and N will converge so fast, even in the most unfavourable case that occurs in the theory of the planets, that the first three terms will give the sums sufficiently exact ; and it will therefore not be necessary to have recourse to the more converging series A'' and B''.

SUCH is the method that I had first imagined, for facilitating these sort of computations. I have since found, however, that by means of the common tables of sines and tangents, the quantities A and B may be computed in a still easier way from the expressions,

$$A = (1 + c') (1 + c'') (1 + c''') \&c.$$

$$B = c \times \left(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \cdot \frac{c'''}{2} + \&c. \right) \times A.$$

For if $c = \sin m$, then $\sqrt{1 - c^2} = \cos m$ and $c' = \frac{1 - \cos m}{1 + \cos m} = \tan^2 \frac{m}{2}$: consequently $1 + c' = \sec^2 \frac{m}{2}$. In like manner, if $c' = \sin m'$, $c'' = \sin m''$, &c. we shall have $\sin m' = \tan^2 \frac{m}{2}$;

$\sin m''$

$\sin m'' = \tan^2 \frac{m'}{2}$, and so on: And $1 + c' = \sec^2 \frac{m}{2}$; $1 + c'' = \sec^2 \frac{m'}{2}$, and so on. Thus:

$$A = \sec^2 \frac{m}{2} \times \sec^2 \frac{m'}{2} \times \sec^2 \frac{m''}{2} \times \&c.$$

To find the logarithm of A , we have then only to add together the logarithm secants of the angles $\frac{m}{2}, \frac{m'}{2}, \frac{m''}{2}$, &c. to diminish the sum by as many times the radius as there are secants, and to take twice the remainder. As the angles m, m', m'' , &c. decrease very fast, it will seldom be necessary to compute more than two or three of them.

THE series $(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \cdot \frac{c'''}{2} + \&c.)$ is also readily computed from the tables; because the logarithms of c', c'', c''' , &c. being the sines of the angles m', m'', m''' , &c. are all found in the tables.

As an example, let $c = 0.72333$: which is the fraction that arises from dividing the mean distance of Venus from the sun, by the mean distance of the Earth; and this is the most unfavourable case that occurs in the theory of the planets: Then to compute A , I find, in the table of natural sines, that 0.72333 corresponds to $46^\circ 19' 48\frac{1}{2}''$: we have therefore

$m = 46^\circ 19' 48\frac{1}{2}''$	
L. $\tan \frac{m}{2} = \text{L. } \tan 23^\circ 9' 54\frac{1}{2}'' = 9.6313206$	L. $\sec \frac{m}{2} = 10.0365070$
	2
L. $\sin m' = 9.2626412$	
L. $m' = 10^\circ 32' 57''$	
L. $\tan \frac{m'}{2} = \text{L. } \tan 5^\circ 16' 28\frac{1}{2}'' = 8.9652949$	L. $\sec \frac{m'}{2} = 10.0018429$
	2
L. $\sin m'' = 7.9305898$	
L. $m'' = 0^\circ 29' 18''$	

L. tan

190 RECTIFICATION of the ELLIPSIS, &c.

$$L. \tan \frac{m''}{2} = L. \tan 0^\circ 14' 39'' = 7.6295664 \quad L. \sec \frac{m''}{2} = 10.0000039$$

$$L. \sin m''' = 5.2591328 \quad \frac{2}{0.0383538}$$

As m''' will only be a few seconds, it may be neglected.

$$\text{Hence } A = 1.19318$$

To compute B, let $S = 1 + \frac{c'}{2} + \frac{c'^2}{2} + \frac{c'^3}{2} + \&c.$

$$L. c' = L. \sin m' = 9.2626412; \quad \frac{c'}{2} = 0.091540$$

$$L. c'' = L. \sin m'' = 7.9305898; \quad \frac{c''}{2} = 0.0000390$$

$$1. c' \cdot c'' = 7.1932310 \quad S = 1.091830$$

$$B = c \times S \times A.$$

$$L. c = 1.8593365$$

$$L. S = 0.0381948$$

$$L. A = 0.0767076$$

$$L. B = 1.9742389, \text{ and } B = 0.942408$$

IX.

side of the mountain is a series of rugged slopes, interspersed with abrupt precipices. The northern extremity is perfectly perpendicular, except towards the north-west, where the line of the precipice is interrupted by a narrow passage of the ground that leads to the summit, and is entirely covered with forest. The eastern side of the mountain mostly consists of a

IX. *A SHORT MINERALOGICAL DESCRIPTION of the MOUNTAIN of GIBRALTAR. By Major IMRIE. Communicated by the Reverend JOHN WALKER, D. D. Professor of Natural History in the University of Edinburgh.*

[Read July 3. 1797.]

THE mountain of Gibraltar is situated in $36^{\circ}. 9'$ north latitude, and in $5^{\circ}. 17'$ east longitude from Greenwich. It is the promontory which, with that of Ceuta upon the opposite coast of Barbary, forms the entrance of the Straits of Gibraltar from the Mediterranean; and Europa Point, which is the part of the mountain that advances most towards Africa, is generally regarded as the most southern promontory in Europe. The form of this mountain is oblong; its summit a sharp craggy ridge; its direction is nearly from north to south; and its greatest length, in that direction, falls very little short of three miles. Its breadth varies with the indentations of the shore, but it no where exceeds three quarters of a mile. The line of its ridge is undulated, and the two extremes are somewhat higher than its centre.

The summit of the Sugar Loaf, which is the point of its greatest elevation towards the south, is 1439 feet; the Rock Mortar, which is the highest point to the north, is 1350; and the Signal House, which is nearly the central point between these two, is 1276 feet above the level of the sea. The western side

side of the mountain is a series of rugged slopes, interspersed with abrupt precipices. Its northern extremity is perfectly perpendicular, except towards the north-west, where what are called the Lines intervene, and a narrow passage of flat ground that leads to the isthmus, and is entirely covered with fortification. The eastern side of the mountain mostly consists of a range of precipices; but a bank of sand, rising from the Mediterranean in a rapid acclivity, covers a third of its perpendicular height. Its southern extremity falls, in a rapid slope, from the summit of the Sugar Loaf, into a rocky flat, of considerable extent, called Windmill Hill. This flat forms half an oval, and is bounded by a range of precipices, at the southern base of which a second rocky flat takes place, similar in form and extent to Windmill Hill; and also, like it, surrounded by a precipice, the southern extremity of which is washed by the sea, and forms Europa Point. Upon the western side, this peninsular mountain is bounded by the bay of Gibraltar, which is in length nearly eight miles and a half, and in breadth upwards of five miles. In this bay the tide frequently rises four feet. Upon the north the mountain is attached to Spain by a low sandy isthmus, the greatest elevation of which, above the level of the sea, does not exceed 10 feet, and its breadth, at the base of the rock, is not more than three quarters of a mile. This isthmus separates the Mediterranean, on the east, from the bay of Gibraltar on the west.

THIS mountain is much more curious in its botanical, than in its mineralogical productions. In respect to the first, it connects, in some degree, the Flora of Africa with that of Europe. In respect to the latter, it produces little variety; perhaps a few substances and phenomena that are rare, but none that are peculiar.

THE principal mass of the mountain rock consists of a grey, dense (what is generally called primary) marble; the different beds

beds of which are to be examined in a face of 1350 feet of perpendicular height, which it presents to Spain in a conical form. These beds, or strata, are of various thickness, from 20 to upwards of 40 feet, dipping in a direction from east to west, nearly at an angle of 35 degrees. In some parts of the solid mass of this rock, I have found testaceous bodies entirely transmuted into the constituent matter of the rock, and their interior hollows filled up with calcareous spar; but these do not occur often in its composition, and its beds are not separated by any intermediate strata.

In all parts of the globe, where this species of rock constitutes large districts, it is found to be cavernous. The caves of Gibraltar are many, and some of them of great extent. That which most deserves attention and examination is called St Michael's Cave, which is situated upon the southern part of the mountain, almost equally distant from the Signal Tower and the Sugar Loaf. Its entrance is 1000 feet above the level of the sea: This entrance is formed by a rapid slope of earth, which has fallen into it at various periods, and which leads to a spacious hall, incrusted with spar, and apparently supported in the centre by a large massy stalactitical pillar. To this succeeds a long series of caves of difficult access. The passages from the one to the other of these are over precipices, which can only be passed by the assistance of ropes and scaling ladders. I have, myself, passed over many of these to the depth of 300 feet from the upper cave; but at that depth the smoke of our torches became so disagreeable, that we were obliged to give up our pursuit, and leave caves still under us unexamined. In these cavernous recesses, the formation and process of stalactites is to be traced, from the slimy quilt-like cone, suspended from the roof, to the robust trunk of a pillar, three feet in diameter, which rises from the floor, and seems intended by nature to support the roof from which it originated.

THE variety of form, which this matter takes, in its different situations and directions, renders this subterraneous scenery strikingly grotesque, and in some places beautifully picturesque. The stalactites of these caves, when near the surface of the mountain, are of a brownish yellow colour; but, as we descended towards the lower caves, we found them begin to lose their darkness of colour, which by degrees shaded off to a whitish yellow.

THE only inhabitants of these caves are bats, some of which are of a large size. The soil, in general, upon the mountain of Gibraltar, is but thinly sown; and in many parts that thin covering has been washed off by the heavy autumnal rains, which have left the superficies of the rock, for a considerable extent, bare and open to inspection. In those situations, an observing eye may trace the effects of the slow, but constant, decomposition of the rock, caused by its exposure to the air, and the corrosion of sea-salts, which, in the heavy gales of easterly winds, are deposited with the spray on every part of the mountain. Those uncovered parts of the mountain rock also expose to the eye a phenomenon worthy of some attention, as it tends clearly to demonstrate, that, however high the surface of this rock may now be elevated above the level of the sea, it has once been the bed of agitated waters. This phenomenon is to be observed in many parts of the rock, and is constantly found in the beds of torrents. It consists of pot-like holes, of various sizes, hollowed out of the solid rock, and formed apparently by the attrition of gravel or pebbles, set in motion by the rapidity of rivers, or currents in the sea. One of those, which had been recently laid open, I examined with attention. I found it to be five feet deep, and three feet in diameter; the edge of its mouth rounded off as if by art, and its sides and bottom retaining a considerable degree of polish. From its mouth, for three and a half feet down, it was filled with a red argillaceous earth,

VI. thinly

thinly mixed with minute parts of transparent quartz crystals; the remaining foot and a half, to the bottom, contained an aggregate of water-worn stones, which were from the size of a goose's egg to that of a small walnut, and consisted of red jaspers, yellowish white flints, white quartz, and bluish white agates, firmly combined by a yellowish brown stalactitical calcareous spar. In this breccia I could not discover any fragment of the mountain rock, or any other calcareous matter, except the cement with which it was combined. This spot is 940 feet above the level of the sea.

UPON the west side of the mountain, towards its base, some strata occur, which are heterogenous to the mountain rock: the first, or highest, forms the segment of a circle; its convex side is towards the mountain, and it slopes also in that direction. This stratum consists of a number of thin beds; the outward one, being the thinnest, is in a state of decomposition, and is mouldering down into a blackish brown or ferruginous coloured earth. The beds, inferior to this, progressively increase in breadth to 17 inches, where the stratification rests upon a rock of an argillaceous nature.

THIS last bed, which is 17 inches thick, consists of quartz of a blackish blue colour, in the septa or cracks of which are found fine quartz crystals, colourless, and perfectly transparent. These crystals are composed of eighteen planes, disposed in hexangular columns, terminated at both extremities by hexangular pyramids. The largest of those that I have seen does not exceed two-eighths of an inch in length: They, in general, adhere to the rock by the sides of the column, but are detached without difficulty. Their great degree of transparency has obtained them the name of Gibraltar diamonds.

AT no great distance from where these crystals are found, upon the same slope of the mountain, but rather nearer to the level of the sea, a stratum of argillaceous matter has been laid

open, divided into many thin beds, the broadest of which does not exceed a foot in thickness. Its general colour is of a whitish grey, with a small mixture of yellow, and it is divided transversely by straight septa or cracks, both sides of which are covered with dendritical figures, of a yellowish brown colour, beautifully representing the objects of landscape. At the western base of the mountain, on a level with the sea by which it is washed, a very extensive stratum occurs, of the same nature as the last described, bearing from north to south, parallel with, and dipping towards, the mountain, nearly at an angle of 40 degrees.

IN some parts of the western slope of the mountain, towards the south, are found nests of a dark red shivery clay, in which are embedded flints of a dirty sap-green colour: Of those no regular stratum is to be perceived; many of them are unshapely masses; but they, in general, tend to the rhomboidal form, and are from three to four inches long, by two or three broad, and an inch and a half thick. They are not incrustated as the flints found in chalk, nor have they the appearance of having been worn by attrition.

UPON different parts of the mountain, towards its base, are found large quantities of sand, composed of different materials, and assuming various appearances as to colour. The largest bank of this arenaceous matter is upon the western side of the mountain, and consists of small particles of crystallized quartz, colourless, and perfectly transparent *per se*, but of an ochreous colour in the mass, on account of a red argillaceous earth which adheres to them. The sand of this bank is perfectly loose and uncombined: one half of it has been levelled into an extensive parade, its surface having been combined by the lime and rubbish from the ruins of the town. The southern extremity of the bank is still to be seen in its natural state, and forms the burying-ground of the garrison.

UPON

UPON the east side of the mountain is found another of these banks, of considerable extent, and, as I mentioned before, rising from the Mediterranean in a rapid acclivity, and reaching to one-third of its entire elevation. This bank is composed of small particles of crystallized quartz, of testaceous bodies rounded by attrition, and of a few minute particles of the calcareous rock; the whole has a whitish grey colour. The rain-water, which falls from the bare mountain rock above the sand, brings along with it calcareous matter, which is deposited upon the bank, and combines its surface into a crust, which in some places is so much indurated as to bear the pressure of the foot.

IN other parts of the mountain, where this sand is surrounded by the calcareous rock, and covered in and protected from the action of the air, and corrosion of the sea-salts, it is found in a perfect indurated state, combined by stalactitical spar, and forming a minute breccia. A quarry of this arenaceous stone has been opened upon the south-east quarter of the mountain, and is made use of, with great propriety, to line the embrasures of some of the new works belonging to the garrison. Its inaptitude to fly off in splinters, when struck by a ball, gives, in such situations, additional safety to the defenders of the place.

THE western side of the mountain's base, around Rosia Bay, and the new Mole, is a rock composed of an aggregate of small fragments of every fossil that has been here described, with the addition of two different species of marble that are probably adventitious, as their native beds have not been found in the mountain. The one of those is black, and the other of an olive green colour. The whole of this mixture produces a most beautiful breccia, and is firmly combined by a calcareous cement of a yellow, verging towards an orange colour. It is susceptible of a high polish, except where fragments of the argillaceous strata occur: These can be easily smoothed down, but cannot be brought to a perfect polish. The fragments in this breccia are angular,

angular, and none of them have the appearance of being water-worn.

It only now remains for me to mention what are generally called the fossil bones, found in the rock of Gibraltar. These have been much talked of, and by some looked upon as a phenomenon beyond the power of explanation. The general idea, which exists concerning them, is, that they are found in a petrified state, and inclosed in the solid calcareous rock; but these are mistakes, which could only arise from inaccurate observation and false description.

IN the perpendicular fissures of the rock, and in some of the caverns of the mountain, (all of which afford evident proofs of their former communication with the surface), a calcareous concretion is found, of a reddish brown ferruginous colour, with an earthy fracture, and considerable induration, inclosing the bones of various animals, some of which have the appearance of being human. These bones are of various sizes, and lie in all directions, intermixed with shells of snails, fragments of the calcareous rock, and particles of spar; all of which materials are still to be seen in their natural uncombined states, partially scattered over the surface of the mountain. These having been swept, by heavy rains at different periods, from the surface into the situations above described, and having remained for a long series of years in those places of rest, exposed to the permeating action of water, have become enveloped in, and cemented by, the calcareous matter which it deposits.

THE bones, in this composition, have not the smallest appearance of being petrified; and if they have undergone any change, it is more like that of calcination than that of petrification, as the most solid parts of them generally admit of being cut and scraped down with the same ease as chalk.

BONES combined in such concretions are not peculiar to Gibraltar: They are found in such large quantities in the country
of

of Dalmatia, and upon its coasts in the islands of Cherso and Osero, that some naturalists have been induced to go so far as to assert, that there has been a regular stratum of such matter in that country, and that its present broken and interrupted appearance has been caused by earthquakes, or other convulsions, experienced in that part of the globe. But, of late years, a traveller, (Abbé ALBERTO FORTIS), has given a minute description of the concretion in which the bones are found in that country: And by his account it appears, that with regard to situation, composition and colour, it is perfectly similar to that found at Gibraltar. By his description it also appears, that the two mountain rocks of Gibraltar and Dalmatia consist of the same species of calcareous stone; from which it is to be presumed, that the concretions in both have been formed in the same manner and about the same periods.

PERHAPS if the fissures and caves of the rock of Dalmatia were still more minutely examined, their former communications with the surface might yet be traced, as in those described above; and, in that case, there would be at least a strong probability, that the materials of the concretions of that country have been brought together by the same accidental cause, which, in my opinion, has collected those found in the caverns of Gibraltar. I have traced, in Gibraltar, this concretion, from the lowest part of a deep perpendicular fissure, up to the surface of the mountain. As it approached to the surface, the concretion became less firmly combined, and, when it had no covering of the calcareous rock, a small degree of adhesion only remained; which was evidently produced by the argillaceous earth, in its composition, having been moistened by rain and baked by the sun.

THE depth, at which these materials had been penetrated by that proportion of stalactitical matter, capable of giving to the concretion its greatest adhesion and solidity, I found to vary according to its situation, and to the quantity of matter to be combined.

bined. In fissures, narrow and contracted, I found the concretion possessing a great degree of hardness at six feet from the surface; but in other situations more extended, and where a larger quantity of the materials had been accumulated, I found it had not gained its greatest degree of adhesion at double that depth. In one of the caves, where the mass of concretion is of considerable size, I perceived it to be divided into different beds, each bed being covered with a crust of the stalactitical spar, from one inch to an inch and a half in thickness, which seems to indicate, that the materials have been carried in at various periods, and that those periods have been very remote from each other.

At Rofia Bay, upon the west side of Gibraltar, this concretion is found in what has evidently been a cavern, originally formed by huge unshapely masses of the rock, which have tumbled in together. The fissure, or cavern, formed by the disruption and subsidence of those masses, has been entirely filled up with the concretion, and is now exposed to full view by the outward mass having dropped down, in consequence of the encroachments of the sea. It is to this spot that strangers are generally led to examine the phenomenon; and the composition, having here attained to its greatest degree of hardness and solidity, the hasty observer, seeing the bones inclosed in what has so little the appearance of having been a vacuity, examines no further, but immediately adopts the idea of their being incased in the solid rock. The communication from this former chasm, to the surface from which it has received the materials of the concretion, is still to be traced in the face of the rock, but its opening is at present covered by the base of the line wall of the garrison. Here bones are found that are apparently human; and those of them that appear to be of the legs, arms, and vertebræ of the back, are scattered among others of various kinds and sizes, even down to the smallest bones of small birds. I found here the complete jaw-bone of a sheep; it contained its
full

full complement of teeth, the enamel of which was perfect, and its whiteness and lustre in no degree impaired. In the hollow parts of some of the large bones was contained a minute crystallization of pure and colourless calcareous spar; but, in most, the interior part consisted of a sparry crust of a reddish colour, scarcely in any degree transparent.

At the northern extremity of the mountain, the concretion is generally found in perpendicular fissures. The miners there, employed upon the fortifications, in excavating one of those fissures, found, at a great depth from the surface, two skulls, which were supposed to be human; but, to me, one of them, if not both, appeared to be too small for the human species. The bone of each was perfectly firm and solid; from which it is to be presumed, that they were in a state of maturity before they were inclosed in the concretion. Had they appertained to very young children, perhaps the bone would have been more porous, and of a less firm texture. The probability is, that they belonged to a species of monkey, which still continues to inhabit, in considerable numbers, those parts of the rock which are to us inaccessible.

THIS concretion varies, in its composition, according to the situation in which it is found. At the extremity of Prince's Lines, high in the rock which looks towards Spain, it is found to consist only of a reddish calcareous earth, and the bones of small birds cemented thereby. The rock around this spot is inhabited by a number of hawks, that, in the breeding season, nestle here, and rear their young; the bones in this concretion are probably the remains of the food of those birds. At the base of the rock, below King's Lines, the concretion consists of pebbles of the prevailing calcareous rock. In this concretion, at a very considerable depth under the surface, was found the under parts of a glass bottle, uncommonly shaped, and of great thickness; the colour of the glass was of a dark green.

IN many parts of the rock I have found concretions, in which there are no bones of any kind; and on the elevated parts of the mountain, where the slopes are rapid, I have found a breccia, (if I may so call it), entirely consisting of snail-shells, combined in a mass of opaque stalactitical spar of a yellowish brown colour. The various progressive augmentations of this matter were to be traced in various shades of the same colour, which, like the zones of the antique alabaster, curve round, and follow the form of the shell. The purer matter of this spar has penetrated the shells, and in their interior hollows has formed a lining of small crystals, generally colourless and perfectly transparent.

I HAVE bestowed more time in endeavouring to describe the composition, and the real situation, of this concretion of bones, than the subject, in the estimation of many, will seem to deserve, and indeed more than it deserves in my own opinion; but where an erroneous opinion has obtained a footing, in consequence of inaccurate observations and partial description, it is the duty of every new observer to endeavour to correct it.

X. DESCRIPTION of a THERMOMETER, which marks the greatest DEGREE of HEAT and COLD, from one TIME of OBSERVATION to another, and may also register its own

HEIGHT at every INSTANT. By ALEXANDER KEITH,

E/q; F. R. S. & F. A. S. EDIN.

[Read August 3. 1795.]

THERMOMETERS have hitherto been defective for meteorological purposes, in so far as they only point out the degree of heat at the moment of inspecting them, but do not show what the difference of temperature has been, from the time of one observation to that of another: Nor has any instrument been yet constructed, so far as I have been able to learn, which will record the intermediate degrees of heat.

THE ingenious ROBERT HOOK, in the end of the last century, mentions his intention of making a thermometer for the above purpose; but it does not appear that it was ever executed: Neither does he explain how it was to have been done.

THE thermometer, invented by M. JAMES SIX, as described in the 72d volume of the *Philosophical Transactions* of the Royal Society of London, is made to show its greatest rise or fall from one period of observation to another. This is done by means of two small pieces of black glass, which float on two different

surfaces of mercury, within two glass tubes hermetically sealed. These floats, when raised to their greatest height, adhere to the side of the tube, by means of a spring of glass, and become stationary, although the mercury falls. After the observer has taken a note of the temperature, he, by a magnet held in his hand, draws down the float to the surface of the mercury, in consequence of a small bit of steel wire inclosed in the float, and the instrument is prepared for another observation. This is an ingenious invention, but requires too delicate workmanship to be fit for common use; besides, it cannot be made to record the degrees of heat at intermediate periods. The thermometer, lately invented by Dr RUTHERFORD of Balilish, and described in the 3d volume of the *Transactions* of this Society, is also an ingenious contrivance, but has the same defect of marking only the extreme points, to which the liquor has risen or fallen, in two separate glass tubes.

SEVERAL years ago it occurred to me, that an air thermometer might be used for the purposes required, providing the weight of the atmosphere could be excluded, or a counter-balance formed to it; and as the whole instrument could be made to rise and fall by the temperature of the atmosphere alone, it might be adapted to a piece of clock-work, which would record the degrees of heat at every instant through the year: And accordingly I read to this Society a description of the instrument. But having formed another instrument, of a more simple construction, to answer the same purpose, I beg leave to give a description of it.

AB is a tube about 14 inches long, (Pl. VI.) and three-fourths of an inch caliber, of thin glass, sealed or close at top. To the bottom, which is bent upwards, there is joined a glass tube 7 inches long, and four-tenths of an inch caliber, open at top. The tube

AB

AB is filled with the strongest spirit of wine or alcohol, and from B to E is filled with mercury.

It will be evident, from inspection, that if the spirit of wine is expanded by heat, the mercury in the smaller tube will rise, and, if the spirit of wine is contracted by cold, the mercury will fall: And although they are both subjected to the pressure of the atmosphere, yet, as liquids are incompressible by weight in any perceptible degree, neither the spirit of wine nor mercury will be altered in bulk by the different weight of the atmosphere.

FD is a scale of brass or ivory, about $6\frac{1}{2}$ inches long, divided in the usual way.

E is a small conical piece of ivory or glass, of a proper weight, made to float on the surface of the mercury in the smaller tube: to which float is joined a wire, reaching to H, having a knee bent at a right angle, which raises one index, and depresses another index, according as the mercury rises or falls, which wire shall be termed the *float-wire*.

It is a glass tube, 7 inches and a half long, closed at top and open at bottom, so wide as to slide easily over the scale, and, by means of a brass rim cemented to it, is made to fit exactly to the circular base of the scale, so that, when this tube is put on, it covers the whole scale and indexes, and defends them from wind or rain. This cover need not be taken off, except when the instrument is to be prepared for an observation.

THE operation of the float and indexes will be better understood from fig. 2. which represents them of the full size.

FG is the scale fixed to a circular piece of wood or brass, through which the top of the small tube is made to pass.

FROM G to K is a piece of the smallest harpsichord wire, or rather of the smallest gold wire, stretched along the scale, fixed at the ends by two brass pins.

LI. are two indexes, formed of thin black oiled silk, pierced by the small wire in such a manner as to slide upwards and downwards with a very small force, not more than two grains.

H, the knee of the float-wire before described, is made to encompass the small wire between the two indexes, so that, when the float rises, the upper index is moved upwards, and, when it descends, it leaves the upper index stationary, and pushes down the lower index, which is also left stationary, when the float rises.

WHEN the instrument is to be prepared for an observation, the one index is to be pulled down, and the other raised, by means of a bit of wire bent for the purpose, until both indexes touch the knee of the float-wire: And, when it is again observed, the upper index will point out the greatest degree of heat, and the lower the greatest degree of cold, since the time they were set.

If this thermometer is to be adapted to a piece of clock-work, in order to record the degrees of heat at each hour and minute of time, it ought to be made of larger dimensions. The large tube may be 40 inches long, and not increased in diameter, but the small tube ought to be enlarged in diameter, and not in length. By enlarging the tube, which contains the spirit of wine, in length only, it will be affected by heat and cold in as short a time as that before described.

It is unnecessary at present to explain the clock-work. It is sufficient to say, that a hollow cylinder of any light substance, 7 inches long, and 5 inches diameter, is made to revolve upon a vertical axis once in thirty-one days or a month; a piece of smooth or vellum paper is put round this cylinder, pasted only at the joining, but so as to make it adhere close to the cylinder; on this paper are drawn thirty-one equal perpendicular divisions, numbered at the top 1, 2, 3, &c. to correspond to the thirty-one days of the month, each of which is subdivided into six parts, to answer to four hours. The length of this cylinder

is divided by lines surrounding it, or zones, in such number as correspond to the scale of FAHRENHEIT's thermometer, viz. from 0 to 100 degrees. These divisions ought to be engraved on copperplate, and a great number of impressions thrown off on smooth or vellum paper, in order that one may be ready to put on each month.

FIG. 3. MN represents the cylinder covered with one of these impressions. PP is the scale fixed to the frame on which the cylinder turns. This scale is divided into 100 of FAHRENHEIT's degrees, exactly corresponding to the divisions of the cylinder.

Q is a piece of black-lead pencil, joined to the end of the shot-wire in the place of the knee before mentioned. This pencil is made to press lightly on the cylinder, by means of the small weight R. And as the pencil rises or falls by heat and cold, it will mark the degrees on the scale of the cylinder; and the cylinder being constantly revolving, the division for each day and parts of a day will successively be marked by the pencil, which will leave a trace, describing an undulated line, distinctly delineating the temperature of each day through the month. These papers, when taken off and bound together, will make a complete register of the temperature for the year; or, if they are pasted to one another, they will form a thermometrical chart, by which the variations of heat and cold, during the year, may all be seen and compared by one glance of the eye.

By inspecting fig. 3. the effect of the instrument may be seen. It appears that the paper had been put on the cylinder the first day of the month, at midday, when the thermometer stood at 45° ; that it fell gradually till midnight to 25° ; thereafter it rose till the 2d at 1 P. M. when it stood at 42° ; then it descended at midnight to 35, &c.; that on the 4th, at midday, it rose to 50; and at noon, the 10th of the month, it stands at 40° .

If three inches be added to the length of the cylinder, it may be made to delineate the variations of the barometer as well as the thermometer, and thereby to form a complete chart or view of the progress of both of them. And if instruments of this kind were kept in different parts of the country, and their charts compared together, it would afford much information with regard to meteorology.

XI.

Fig. 1^a

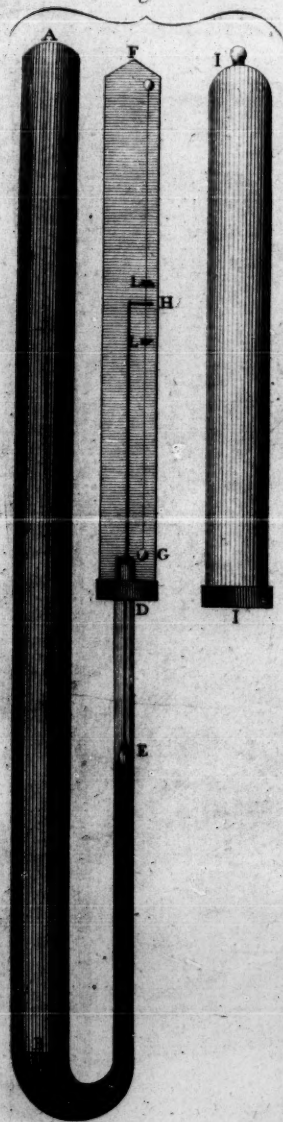


Fig. 2^a

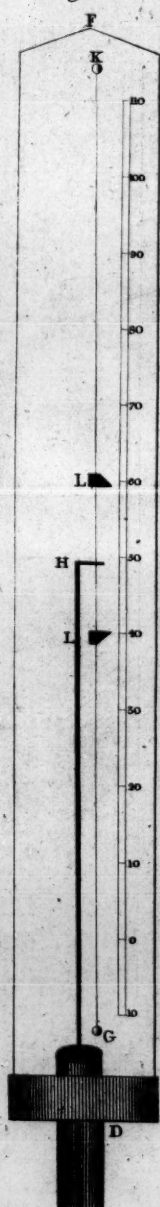


Fig. 3^a

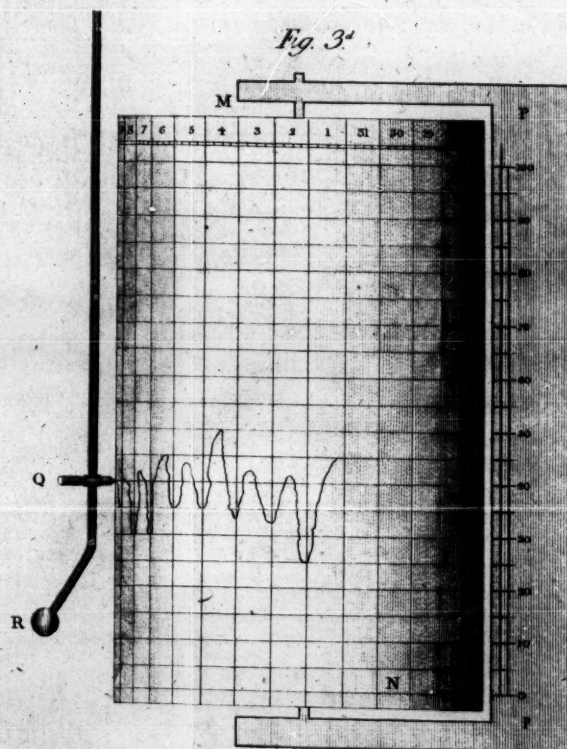


Fig. 4^a

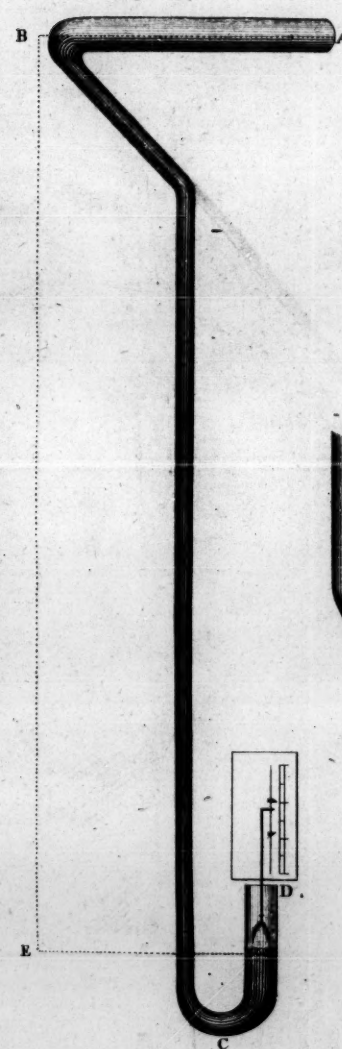
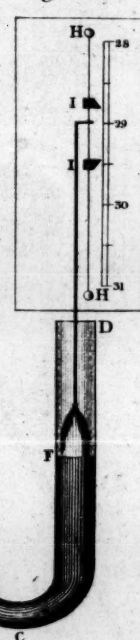


Fig. 5^a



XI. DESCRIPTION of a BAROMETER, which marks the RISE and FALL of the MERCURY from two different TIMES of OBSERVATION. By ALEXANDER KEITH, Esq; F.R.S. & F. A. S. EDIN.

[Read Jan. 5. 1796.]

IN August last, I read to this Society the Description of an Air Thermometer, intended to record the various degrees of heat at every instant; and mentioned my intention of constructing a barometer, which would, in the same manner, record the variations of the weight of the atmosphere: Both which I proposed to adapt to one piece of clock-work.

THIS piece of machinery appearing too complicated and expensive for general use, I contrived a *thermometer*, which marks the extreme points of heat and cold from any two times of observation. Of which instrument I also lately read an account, and produced the machine itself.

I NOW intend further to lay before this Society the description of a *barometer* upon similar principles, of a very simple construction, which also marks the variation of the atmosphere from one time of observation to another.

FIG. 4. ABCD is a glass tube, bent in the manner represented, open at D, and hermetically sealed at A. From A to B is 8 inches long, and about $\frac{3}{4}$ of an inch caliber. From B to C $3\frac{1}{4}$ inches long, and about $\frac{1}{4}$ of an inch caliber. And from C to D $4\frac{1}{2}$ inches long, and $\frac{1}{2}$ inch caliber.

THE tube is filled with mercury, the length from B to E being $29\frac{1}{2}$ inches. When the tube is hung perpendicular, the mercury will fall from B to E, leaving a vacuum in the upper half of the tube from B to A. When the atmosphere becomes heavier, the mercury falls in the tube DC, and when lighter it rises. The range of the scale is about 3 inches, being equal to that of a common barometer of the best construction, which has a basin with a very broad surface. This instrument moves in a direction contrary to the common barometer, the one rising while the other falls.

FIG. 5. represents the tube DC, with the scale placed above it, of half the real dimensions. F is a piece of ivory or glass, of a conical shape, of a proper weight, made to float on the surface of the mercury, having a wire fixed to it reaching to G. From H to I is a piece of small harpsichord-wire, or rather gold-wire, stretched along the ivory or brass plate on which the scale is engraved. II are two indexes formed of the thinnest black oiled silk, pierced in such a manner by the small wire as to move upwards and downwards upon it with a very small force, not more than two grain weight; and these indexes, being not the weight of half a grain, they do not descend the wire by their own weight, but remain where they are placed.

THE wire fixed to the float, (which we shall call the float-wire), has a knee bent at a right angle, and made to encompass the small wire between the two indexes, so that, when the float rises, the upper index is carried up, and, when it falls, it leaves the upper index, and pushes down the under index.

IN order to prepare this barometer for an observation, the one index is to be brought down, and the other raised, until both touch the knee of the float-wire.

THE next time the instrument is observed, the upper index will point out the greatest depression of the mercury, or lightness of the atmosphere, and the lower index the greatest rise of the mercury or weight of the atmosphere, from the time the scale was prepared.

By this means the variations of the atmosphere are much more truly pointed out than by the common barometer. For it often happens, that, during tempestuous weather, or before it, the mercury both rises and falls within the space of a few hours, or during the night time, which variations cannot be discovered by any of the barometers presently in use.

DURING the late very high winds, in November and December last 1795, I have frequently observed the mercury to rise and fall within the space of two or three hours before the wind begins; and, during tempestuous weather, it will fall very considerably, and soon after rise higher than before, and oscillate, or rather undulate, upwards and downwards, the undulations becoming gradually less, until the atmosphere is more settled; which shows, that, like other fluids, when put in agitation, it undulates till it come near an equilibrium; for it appears seldom to be in a state of perfect tranquillity.

THE sudden fall and rise, or even the rise and fall of the mercury, always denote an extraordinary agitation in the atmosphere. And therefore, to foretell tempestuous weather, it becomes of importance to observe how many degrees the one index is removed from the other; for example, at night, I take note of the common barometer as standing at $29\frac{1}{2}$ inches, and when I examine it in the morning find it at the same height; from which I naturally conclude, that, as there has been no agitation of the mercury, there will be calm or settled weather.

ther. But, if I use the barometer before described, and examine it in the morning, I find the common barometer has deceived me; for although the surface of the mercury stands at $29\frac{1}{2}$ inches, yet I observe, that one of the indexes has been raised $\frac{1}{10}$, and the other lowered $\frac{1}{10}$ during the night. Hence, instead of denoting calm weather, it shows that, the mercury having been agitated, tempestuous weather is to be expected.

THE register of the weather, kept from an instrument of this kind, will be much more satisfactory than those hitherto used, and registers kept at different places can be more accurately compared with one another.

THE levity of the atmosphere, at great heights, might also be discovered, by suspending this instrument to an air-balloon.

**XII. METEOROLOGICAL ABSTRACT for the YEARS 1794, 1795,
and 1796. Communicated by JOHN PLAYFAIR, F. R. S.
EDIN. and Professor of Mathematics in the University of
Edinburgh.**

[Read at the Meetings in Feb. 1795, 1796, & 1797.]

THE Journal of the Weather, of which an abstract is here communicated, has been kept in a house in Windmill Street, on the south side of Edinburgh. The latitude of Edinburgh College, as deduced from a series of astronomical observations made at Hawkhill, is $55^{\circ}. 57'. 5''$ nearly. Windmill Street is about 500 yards farther to the south.

THE barometer used in these observations is a portable one, of the construction invented by Dr LIND, physician at Windsor; the mercury was boiled in the tube, and the scale is divided into the five-hundredth parts of an inch. The place where it stands is 265 feet above the level of the sea, or of the mean high-water mark at Leith. The height of it is marked every morning at 10 o'clock, as well as that of a thermometer, in the same room, which gives the temperature of the mercury.

THE thermometer, which gives the temperature of the air, is placed on the outside of a window that looks towards the N. W.
about

about 18 feet above the surface of the ground; and though, in a town, it is impossible to prevent local causes from affecting the thermometer, yet the current of air is generally so considerable as to prevent these irregularities from rising to any great amount.

THE register contains the state of the thermometer for three different hours of the day, viz. 8 A. M. 10 P. M and also about 2 o'clock, when the thermometer is highest. The hour of this last observation is not however fixed; it is such as to give nearly the greatest heat of the day, and varies from 1 to half past 2, or even 3 o'clock. The abstract contains the greatest and least heights of the thermometer, that have been observed at any of these hours in the course of each month: It contains also the mean of the morning, mid-day, and evening observations; and likewise the mean of all these means, as being nearly the medium temperature of the whole month.

THE rain is put down for 1794 and 1795 from a rain-gage kept in Edinburgh, and for 1796 from one kept in the Botanic Garden with great accuracy, under Dr RUTHERFORD's particular inspection. The Botanic Garden is half-a-mile north of Edinburgh, and about 100 feet above the level of the sea.

IN the remarks, reference is sometimes made to the Meteorological Journal kept some years ago at Hawkhill, near Edinburgh, of which an account is given in the *Philosophical Transactions of London* 1775, p. 462.

METEOROLOGICAL TABLE FOR 1794.

Months.	Mean Height of the Bar. 8 A. M.	Mean Temp. of the Merc. in Bar.	Greatest Height of the Ther. in the Air.	Least Height of ditto.	Mean Height of Ther. 8 A. M.	Mean Height of Ther. at Noon.	Mean Height of Ther. 10 P. M.	Mean of the last three Means.	Quantity of Rain.
January,	29.661	49.30	51.5	21.0	39.32	41.43	41.20	40.65	1.40
February,	29.397	59.0	54.25	35.5	43.5	46.00	44.30	44.10	2.145
March,	29.631	51.00	53.0	38.5	44.43	48.09	45.93	46.15	0.995
April,	29.595	55.25	64.5	39.25	49.50	52.98	48.30	50.26	2.150
May,	29.752	56.32	62.0	42.0	50.22	56.16	47.22	51.20	1.910
June,	29.884	64.50	73.0	48.5	60.4	62.30	57.40	60.70	1.07
July,	29.768	66.70	75.0	52.0	61.7	66.42	58.61	62.24	2.12
August,	29.720	64.32	72.0	49.0	59.98	63.03	55.40	59.47	1.84
September,	29.662	58.71	64.0	41.0	54.90	57.45	52.06	54.08	3.14
October,	29.516	54.85	62.0	36.5	50.26	52.43	47.29	49.66	3.53
November,	29.416	48.90	53.5	32.5	43.58	45.54	43.47	44.19	4.51
December,	29.691	48.58	50.5	26.25	41.33	42.50	40.10	41.31	3.92
Means,	29.641	55.72			49.79	52.84	48.34	50.32	
Total Rain,									28.73

R E M A R K S.

THE weather in January and February 1794. was very mild and open. The prevailing winds were from S. W. and S. S. W.; usually a brisk steady gale, but sometimes more violent, particularly in February. The thermometer was as high as $50\frac{1}{2}$ in January, and 54 in February; and once in January so low as 21, only for a short time, however, during a N. W. wind; the frost lasted some days. Very little snow fell. The temperature of these months was 6° or 7° above the mean of the Hawkhill observations. There was a great deal of clear weather, and, though the atmosphere was moist, there fell but little rain.

MARCH and April continued to maintain a superiority of 3 or 4 degrees in temperature above the same months in ordinary seasons. March was very dry, and the wind frequently in the east. In the end of April, the weather was squally, with the wind varying from S. W. to S. E.

216 METEOROLOGICAL ABSTRACT.

IN May the heat fell down nearly to the common average of that month, viz. $50\frac{1}{2}$, so that it seemed cold, compared with the rest of the season. The wind was often in the east, and the nights cold.

JUNE and July were very favourable: warmer than the mean by 1 or 2 degrees. In June, the temperature was remarkably uniform; and the wind was mostly in the west. The weather in July was also fine; the wind moderate, and generally west.

THE Harvest began with August; the weather tolerable, though more rainy than usual, and colder. The temperature of this month is almost 2° below the mean.

THE wind was generally west; but a surface wind was to be observed at the same time blowing from the east. This is often observed with us in the finest weather: it seldom fails to happen at the time of the great changes of the wind from the east to the west.

SEPTEMBER was rainy; its temperature rather below the mean, with easterly winds about the middle and end of the month.

OCTOBER rainy; the wind variable, though mostly S. W.; the barometer low; and the mean temperature $49^{\circ}.66$, a very little under the mean.

NOVEMBER was warm for the season, though rainy, with the wind variable, and often very high from S. W.

DECEMBER was also warmer than usual, by nearly two degrees: The wind was easterly till near the end of the month, when it changed to the N. E.: A good deal of snow fell on the 25th; and, on the last day of the year, the thermometer, in the evening, was at 26: The weather clear, with little wind.

ON the whole, the mean temperature of this year exceeded that of ordinary seasons by almost 2° . This excess of heat is very considerable; but, as it fell chiefly in the winter months, it was not attended with any particular advantage. The rain that fell was 28.73 inches.

METEO.

METEOROLOGICAL TABLE FOR 1795.

Months.	Greatest Height of the Bar. at 10 A. M.	Least Height of the Bar. at 10 A. M.	Mean Height of Bar. 10 A. M.	Mean Temp. of Merc. in Barometer.	Greatest Height of Ther. in the Air.	Least Height of Ther. in the Air.	Mean Height of Ther. 8 A. M.	Mean Height of Ther. at Noon.	Mean Height of Ther. 10 P. M.	Mean of the three last Columns.	Quantity of Rain.	Days of westerly wind.	Days of easterly wind.
	Inches.	Inches.	Inches.	°	°	°	°	°	°	°	Inches.		
Jan.	30.306	28.885	29.891	42.0	46.0	16.5	31.11	32.80	31.20	31.70	2.732	14	17
Feb.	30.450	28.636	29.484	41.8	40.0	21.0	30.14	30.89	28.46	29.83	3.875	16	12
March.	30.125	28.992	29.573	46.5	51.5	26.0	39.92	42.96	37.80	40.23	1.372	23	8
April.	30.146	28.948	29.503	52.0	56.5	39.0	47.09	49.52	44.73	47.11	2.110	16	14
May.	30.320	29.275	29.913	55.1	65.5	39.5	50.98	53.83	47.03	50.34	1.200	18	13
June.	30.272	29.128	29.743	57.5	67.0	42.5	54.49	57.17	50.54	54.06	3.920	10	20
July.	30.238	29.286	29.806	60.2	72.0	50.0	60.42	62.85	54.97	59.41	2.520	15	16
Aug.	30.040	29.210	29.674	64.2	73.5	52.0	61.11	64.21	58.58	61.30	3.620	24	7
Sept.	30.282	29.314	29.853	62.0	73.0	53.2	59.89	63.48	57.63	60.00	1.120	21	9
Oct.	29.944	28.340	29.280	57.5	63.5	44.5	53.66	55.55	51.48	53.56	4.870	23	8
Nov.	30.490	28.475	29.570	47.5	51.5	25.2	40.60	41.61	39.27	40.49	4.580	26	4
Dec.	30.220	29.080	29.560	50.5	55.7	36.0	45.43	46.23	42.96	44.87	3.810	25	6
Means,			29.654	53.1			47.90	50.04	45.44	47.75			
Totals,											35.729	231	134

THE mean temperature of the whole year is 47.75.

R E M A R K S.

THE winter of 1795 was remarkable for the severity and continuance of the cold. The year began with a sharp frost, which had set in on the 26th of the preceding month, but which lasted only till the 3d of January, when the wind came round to the S. W. and was followed by a thaw. On the 10th the frost returned, the wind varying from N. W. to N. E. with heavy falls of snow between the 15th and 20th. On the 20th the cold became very severe; and on the 22d the thermometer, about 8 in the evening, stood at $14\frac{1}{2}^{\circ}$, the lowest that I observed it during the whole season. This intensity of the cold lasted, however, but a short time, for by 10 o'clock the thermometer had risen to $16\frac{1}{2}^{\circ}$. On the same night, in the Bo-

tanical Garden, which lies between Edinburgh and the Frith, and is about 150 feet lower than the place where I observed, a thermometer, which marks its lowest point, according to the construction described in the 3d volume of these *Transactions*, fell as low as 5° . The cold at Glasgow, on this night, was still more intense. Mr Professor Wilson, who watched the motions of the thermometer, with his usual diligence and accuracy, found it stand at *zero*, from 11 at night till 3 in the morning, when it began to rise, and about break of day was at 10° .

THE night preceding this was also observed, in some places, to be remarkably cold. At White Hall, in Berwickshire, 7 miles W. N. W. of Berwick upon Tweed, and about 38 E. S. E. of Edinburgh, Mr HALL observed the thermometer, in the open air, about 10 that evening, at 6° below *zero*. This was the greatest cold that I have heard of being observed in Scotland; and is, at the same time, an example of the locality of these great colds. The weather at this time was clear; the wind very gentle, between N. N. W. and N. N. E.; a great deal of snow had fallen from the 15th to the 20th, and lay at this time more than a yard thick on the ground.

FROM about the 22d the intensity of the cold relaxed gradually for several days; the thermometer was a degree above freezing on the 24th. From that time the cold increased; on the 29th the thermometer was at $16\frac{1}{2}^{\circ}$ in the evening; in the Botanic Garden at 4° ; and at Glasgow, on the afternoon of the 30th, it was between 4° and *zero* for several hours together. This was again followed by a relaxation of the cold, though not so considerable as before. On the 5th and 6th of February it was again very cold, the thermometer here was at 19° ; at Glasgow it descended to *zero*.

AFTER another remission the cold became very severe on the 13th, both here and at Glasgow. This was succeeded by a similar change, only the remission was longer and more considerable, so that a good deal of snow was melted on the 24th and 26th; but on the 27th and 28th the cold once more became severe, the thermometer standing at 19 and 20 degrees. It continued much in this state till the 3d of March, when the wind came about to the S. W.; the thermometer rose in the evening to $40\frac{1}{2}^{\circ}$; and a very moderate thaw succeeded, which carried off the snow, without any of those great inundations which did so much mischief in the southern part of the Island.

THE whole duration of the frost was 52 or 53 days; and the medium temperature, during that time, $29^{\circ}.6$. The alternate intensions and remissions of the cold, all the while were very remarkable; our climate seemed to lose nothing of its usual inconstancy, and its vicissitudes were only lower down in the scale of heat. By this means, however, many of the bad consequences of a long and severe winter were prevented. The insides of houses were never so much cooled, that spirits or beer, or even water, was frozen in them. The room where my barometer is kept, though without fire, was never colder than 37° , and this only for a few days in the end of January. From the same cause, the mills in the country were rarely stopped; and, except from the blocking up of the roads by the snow, almost no inconvenience was experienced.

The

The roads were rendered impassable, both from the depth of the snow, and the degree of thaw which now and then took place, by which they became slippery, and uneven in the extreme. The whole snow that fell, reduced to water, measured 6.607 inches, which, had it fallen at once, would have covered the ground to the depth of about 7 feet.

THE severity of this winter extended over all Europe; and, on the Continent, the freezing over of the Rhine and the Meuse was accompanied with circumstances that will be long remembered.

THE barometer was above 30.3 at the beginning of the frost, and continued high till the end of January, notwithstanding the heavy falls of snow, which came almost all from east and N. E. On the 31st of January it fell greatly, with snow; and, during the first 12 days of February, it was generally below 29 inches. It stood at 30.4 on the 17th, from which it fell gradually till the thaw, when it was under 29.5. No connection could be traced between the oscillations of the barometer, and the intensions and remissions of the cold.

FROM the breaking up of the frost on the 3d, till about the 20th of March, the snow did not disappear entirely, even in the plains; it usually froze a little in the night, and the medium temperature was under 38°. On the disappearance of the snow, the thermometer rose suddenly about 10°, which must be ascribed to the ceasing, at that time, of the absorption of the latent heat, that had taken place during the melting of the snow.

THE spring which succeeded was tolerable; and the temperature of the latter part of March, the whole of April, and the beginning of May, rather above the mean. About the 10th of May the wind, which had for some time been in the S. W. came to the east and N. E.; the weather, of course, was cold, and continued so, with the wind generally N. E. all the month of June, and till the 24th of July. June and July were also very rainy months. The westerly winds prevailed in August, and the weather was good, though a considerable quantity of rain fell. September was uncommonly favourable; and the crop, which was extremely late, owed much of its maturity to this month. It proved, however, very scanty, and was got in but indifferently, October being a very rainy month.

NOVEMBER was cold, and very wet: On the 18th the rain was remarkably heavy, and was followed by the greatest floods that had been known for several years. In December the weather became much milder, and somewhat less rainy; but, on the whole, the rain of this year very much exceeded the average, and amounted to 35.729 inches.

N. B. In the two last columns of the table for this year, it is marked whether the wind blew from the western or eastern semicircle. The south wind is supposed to belong to the first of these; the north wind to the second.

METEOROLOGICAL TABLE FOR 1796.

Months.	Greatest Height of the Barometer.	Least Height of the Barometer.	Mean Height of the Barometer.	Mean Temp. of the Merc. in Bar.	Greatest Height of the Thermometer.	Least Height of the Thermometer.	Mean Height of the Ther. at 8 A. M.	Mean Height of the Ther. at Noon.	Mean Height of the Ther. at P. M.	Mean of the three preceding.	Rain in Inches and Decimals.	Days of westerly Wind.	Days of easterly Wind.
Jan.	29.792	28.175	29.194	50.0	56.0	35.0	43.94	47.12	45.94	45.66	3.280	30	1
Feb.	30.380	28.682	29.556	49.0	51.5	34.0	39.85	43.77	40.79	41.47	1.093	16	13
March.	30.408	29.375	28.886	48.5	51.0	30.0	38.35	43.88	38.67	40.30	.414	12	19
April.	30.208	29.040	29.873	56.0	68.25	41.0	48.37	55.40	47.49	50.42	1.156	16	14
May.	29.995	28.530	29.585	56.75	66.5	40.5	47.77	53.60	46.33	49.23	1.852	17	14
June.	30.100	29.315	29.662	59.0	73.0	47.0	53.80	60.20	52.23	55.41	1.070	26	4
July.	30.021	29.054	29.445	61.25	66.5	47.0	55.99	61.45	54.57	57.33	2.305	25	6
Aug.	30.240	29.316	29.828	64.75	74.25	50.0	58.86	68.50	57.22	61.52	.323	26	5
Sept.	30.166	29.362	29.739	61.62	70.5	45.5	54.85	60.12	54.63	56.66	2.187	18	12
Oct.	30.492	29.114	29.339	54.0	62.0	34.0	45.02	50.49	44.47	46.66	1.668	28	3
Nov.	30.322	29.026	29.638	47.75	48.5	26.0	39.0	42.00	39.40	40.13	2.393	19	11
Dec.	30.262	28.978	29.660	40.37	51.5	29.0	31.76	34.05	31.66	32.49	1.664	20	11
Means, Totals,			29.614	54.08			47.38	51.71	47.10	48.1	19.395	253	113

THE mean temperature of the whole year is 48° . 1.

REMARKS.

THE winter of this year was remarkable for its mildness, and, compared with that of the former year, may give an idea of the two extremes between which the winters of this part of the Island will generally be confined. About the middle of January, the thermometer stood for 10 days constantly above 50° , day and night; and the mean temperature of the month, viz. 45° . 6, is at least 11° above the medium, and nearly the same with that of the ordinary January of Marseilles. This extraordinary

nary degree of warmth was maintained by a high wind, that blew constantly from S. W. and S. S. W. bringing with it the air and temperature of the southern parts of the Atlantic. This wind prevailed over such an extent of the ocean, and blew with such violence, that it forced back a fleet of British men of war, after it had endeavoured, in vain, for six weeks, to make its passage to the West Indies.

It must be remembered, that the great cold of the preceding winter was with a wind N. N. E. and sometimes N. N. W. which blew very moderately.

On the 23d of January there was a hurricane from S. S. W. that blew down trees and unroofed houses: The barometer fell very low, and did not rise to its ordinary height for more than ten days.

In March the weather was cold, 5° below the middle temperature of February; east winds prevailed, and the premature appearances of vegetation, produced by the mildness of the preceding season, suffered a severe check. April was more favourable; but in May the weather again became cold, with east winds, remarkably dry and parching. The grass every where suffered extremely from this month.

On the 30th there was a hurricane at London, and at Portsmouth on the 31st. On both these days the barometer here was very low, 28.53, though the wind was no more than a brisk gale at S. W.

In June the mean temperature was not so high by 2° as in ordinary seasons. The wind, though west, was usually from the northern points of the semicircle.

JULY was worse than June, and its mean temperature 3° under that of a tolerable season. Great apprehensions were entertained for the crops, which, without the fine weather that succeeded in August, must have been ruined. The heat of this month, which was at a medium about $61\frac{1}{2}^{\circ}$, was not so remarkable for being great as for being uniform; the thermometer, for a great part of the month, was not below 63° , even in the night. There was a great deal of sunshine, and the wind almost constantly W. S. W.

THE first half of September was little inferior to August. On the 21st, the wind, from the S. W. came round to the N. E.; a considerable fall of rain followed, and the weather became colder, and continued to be so in October: the medium temperature of which was 3 degrees lower than the average.

A SMART frost set in on the 29th of November, and next morning the thermometer stood at 26° . This frost continued till the 10th of December, with an intensity very unusual so early in the winter. On the evening of the 5th the thermometer was at 21° . Between the 10th and 13th the frost had almost disappeared; but it returned on the 14th with considerable severity, and continued till the 28th, when it broke up entirely. The thermometer was at 19° on the 26th, and in many places lower. The same frost was felt in England, where there were local colds of much greater intensity, the thermometer, in some places, having been as low, it was said, as — 10. A tract of very mild and open weather began on the 31st of December.

THE mean temperature of the whole year is $48^{\circ}.1$, about $\frac{1}{2}$ of a degree greater than the common average.

THE greatest singularity in this year is its dryness. The whole rain amounted to no more than 19.395 inches, not much above the half of what fell in 1795. This quantity of rain was, however, perfectly sufficient for the purposes of vegetation, as the crop of corn was very plentiful.

END OF PAPERS OF THE PHYSICAL CLASS.

II.

PAPERS OF THE LITERARY CLASS.

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

PAPERS OF THE LITERARY CLASS.

I. On the ORIGIN and PRINCIPLES of GOTHIC ARCHITECTURE.

By Sir JAMES HALL, Bart. F. R. & A. S. S. EDIN.

[Read April 6. 1797.]

INTRODUCTION.

LONG after the arts of ancient Greece and Rome had been lost, and before any effectual attempt was made to revive them, a style of building, known among us by the name of Gothic Architecture, began to appear in Europe.

At first, a few only of its peculiar forms were employed, which, in some old buildings, are to be met with, intermixed with the remains of a still more ancient style. Afterwards, rising by degrees into favour, it supplanted, in all the departments of architecture, every other species of design, and maintained an unrivalled dominion during three hundred years.

IN the early part of the sixteenth century it underwent a sudden reverse of fortune; not, however, (I am inclined to think), from any discovery of its defects, or any inquiry into its merits, but entirely from the general temper of the times. A passionate admiration of the works of antiquity, which had then recently attracted the attention of the moderns, produced a contempt for whatever was not professedly formed upon the models of Greece and Rome. At the same time, an indiscriminate hatred against every production of the middle ages, strongly felt by men just emerging from the gloom of that period, led them to overlook the merit of this very brilliant exception to its general barbarism.

BUT the excess of these impressions has of late very much abated; authors of the greatest eminence have testified a respect for Gothic architecture, by advancing various systems to account for its forms; and, whilst they acknowledge the superior excellence of the works of the ancient Greeks, they allow that, in airy lightness, and in bold grandeur of effect, those of the Gothic style have not been surpassed, if ever equalled, by the most celebrated of our modern productions. The period, too, in which it prevailed, being at a distance from our times, and that distance being magnified in our imagination by the obscurity of its history, we are inclined to rank its monuments with the works of remote antiquity, which seldom fail to excite even a greater interest than those possessing the charm of novelty.

IN concurrence with these favourable sentiments, my object, in the following Essay, is to restore to Gothic architecture its due share of public esteem, chiefly by shewing, that all its forms may be traced to the imitation of one very simple original; and, consequently, that they are connected together by a regular system: thus proving, that its authors have been guided by principle, and not, as many have alleged, by mere fancy and caprice.

HAVING

HAVING endeavoured to investigate the theory of Gothic architecture, I shall present a view of what I have been able to collect concerning its history; and, without pretending to dispel the very deep obscurity which still surrounds this curious subject, I shall venture to suggest some hints, which may be of service in guiding the researches of antiquaries. By this historical view, I hope, likewise, to refute an opinion, which has contributed greatly to discredit the Gothic style, namely, that it prevailed only in barbarous times; since I shall show, that, although it made its first appearance in a period of that description, it continued to flourish, while the arts of design were advancing in excellence, and still maintained its pre-eminence, when they had attained to the highest degree of modern splendour.

LASTLY, by instituting, between the Gothic and other styles, a comparison, founded upon the general and fundamental principles of architecture, I shall endeavour fairly to appreciate its merits, and to show the high estimation to which it is entitled, in point both of beauty and of utility*.

BEFORE

*THIS plan is now nearly completed, the whole Essay being written out, and accompanied with a set of drawings sufficient to render it intelligible, but by no means in a state for publication. To bring them to such a state must be a work of much labour and time, especially since the nature of the subject has hitherto compelled me to execute all of them with my own hands.

I HAVE judged it advisable, therefore, to lay before the Society a part of the Essay, which requires but few drawings, while it announces the fundamental and essential views of the theory; reserving the full illustration of it to another occasion, when I hope to produce the whole in a separate work.

IN the mean time, it may not be improper to observe, further, with respect to my general plan, that the first part, comprehending the theory of Gothic architecture, has been arranged under three subdivisions; the first of these contains a view of its elements, all its forms being reduced to their simplest state; the second treats of the deviations from those elements, which, in the course of practice, have been occasioned by various circumstances; and, the last, combining the other two, contains an examination

BEFORE we enter upon this inquiry, which is chiefly directed towards the investigation of a principle of Imitation, it will be proper to premise a few observations, on the mode in which the forms of nature have been introduced into works of art; a subject which hitherto seems not to have met with the attention it deserves.

ALTHOUGH the connexion between beauty and utility be still involved in such obscurity, that we are unable to decide concerning the universality of that connexion, of one thing we are certain, that, in a work intended to answer some useful purpose, whatever visibly counteracts that purpose always occasions deformity. Hence it is, that, even where ornament is principally intended, the ostensibly useful object of the work, if it have any such, must be provided for, in the first place, in preference to every other consideration.

BUT, in most useful works, some parts occur, the shape of which is quite indifferent with respect to the proposed utility, and which, therefore, the artist is at liberty to execute as he pleases; a liberty, which has opened a wide field to the taste and invention of ingenious men of every age and country, who have turned their attention to the composition of ornaments; and whose exertions have been more or less influenced by the state of civilization in which they lived. It would seem, however, if we may judge by those various efforts, that little has been effected by mere human ingenuity; since we see, that recourse has been had, almost universally, to Nature, the great and legitimate source of beauty; and that ornament has been attained, by the imitation

mination of the monuments of the art now in existence, and an application of our principles to every part of them.

THE present publication consists of the introduction to the whole Essay, together with the elementary part, illustrated by six plates.

imitation of objects, to which she has given a determinate and characteristic form.

THUS, among the Greeks, in the period of their highest refinement, we find the handles of vases in the shape of vine branches, or of serpents twisted round each other. Some urns of ancient Egyptian workmanship terminate in the head of an owl. The heads of our ships are decorated with figures of men and of animals; and the hatchets and canoes of Nootka Sound are covered with rude images of various natural objects.

THE imitation, however, in such cases, differs from that in a statue or in a picture. In the one, the sole object is to represent some natural object; whereas, in the other, the forms of nature have been partially adopted, and modified in various ways, in order to suit the useful destination of the work. In this manner, artists of every age have been led to select, among the forms of a natural object, such as answered their purpose, to the exclusion of the rest; and have exhibited modified imitations of nature, which, being justified by the circumstances of the case, do not suggest the idea of mutilation. Thus we meet with the foot of a table executed like that of a lion, or the hilt of a sword like the head of an eagle, without asking what has become of the body of the animal, and without being struck with any impropriety in the omission.

FREQUENTLY, where the materials employed are themselves possessed of variety and elegance, the object of ornament has been sufficiently attained, by allowing the natural forms, in whole or in part, to remain in the finished work. For instance, cups are made of shells, of cocoa nuts, or of ostrich eggs, the character and beauty of which depend upon the natural form of the materials. And in the case of the bottles, used by the Roman Catholic pilgrims, an example occurs of an utensil, in which the

the natural form has undergone little or no variation, since it consists of the hard outward skin of a gourd, of the same shape in which it grew upon the plant*.

THIS last class of forms has been introduced, by Imitation, into works composed of shapeless materials. Thus we have silver cups in the form of those made of shells, and fruit-dishes of stoneware in the form of baskets. The ancient Peruvian vases of pottery are executed in exact imitation of gourds; a practice which had probably succeeded the use of gourds as bottles. In such cases, the defect of real character in the object is supplied by a fictitious one, which, in the hands of a man of genius, is often productive of the most happy effects; since it enables him to confer upon his work the merit of consistency, and truth of character; qualities, which influence the mind of the spectator as powerfully, when founded on fiction as on reality. For we judge of such a work, as we do of a romance, in which we are scarcely less interested than if we believed it to be true.

WE may now consider the application of these principles to every kind of ornamental architecture. As stone is not naturally possessed of any peculiar shape, and as the useful object proposed, by structures formed of it, may be accomplished in various ways, very great latitude is left to the invention of the artist. We see, accordingly, that, in every country where much refinement has been introduced, great pains have been bestowed in ornamenting stone buildings, with figures representing various natural objects. It would seem, that the latitude has even been too great; for experience shews, that the

* EVEN in this case, however, the natural form undergoes a certain degree of modification, by the device employed to produce the neck of the bottle. The fruit, while small and tender, is surrounded with a string, which remaining during its growth, prevents the part, thus bound, from swelling with the rest.

artist has succeeded best, where his imagination has been circumscribed, and forced into a regular channel.

For this purpose, recourse has frequently been had to the device last mentioned; the building being executed in imitation of a structure, composed of materials, which naturally possess a determinate and characteristic form. Such was the method followed by the architects of ancient Greece, who constructed temples, and other public edifices, in imitation of a rustic fabric, composed of square beams, supported upon round posts or stems of trees; and who derived the numerous ornaments of that beautiful style, from circumstances which would naturally take place in such a structure*.

VOL. IV.

b

A

* THAT they really did imitate a building of wood, is stated, in the clearest manner, in the work of VITRUVIUS, particularly in his chapter, "De Ornamentis Columnarum." He there speaks of architectural work in stone or marble, as a representation, (*imago*), and of the timber fabric as a reality, (*in veritate*), as will appear by the following quotation.

"ITAEQUE, in Græcis operibus, nemo sub mutulo denticulos constituit, non enim possunt subtus cantherios asseres esse. Quod ergo supra cantherios et templa in veritate debet esse collocatum, id in imaginibus, si infra constitutum fuerit, mendosam habebit operis rationem. Etiamque antiqui non probaverunt neque instituerunt in fastigiis mutulos, aut denticulos fieri, sed puras coronas; ideo quod nec cantherii nec asseres contra fastigiorum frontes distribuuntur, nec possunt prominere, sed ad stillicidia proclinati collocantur.

"ITA quod non potest in veritate fieri, id non putaverunt in imaginibus factum, posse certam rationem habere. Omnia, enim, certa proprietate, et a veris naturæ deductis moribus, traduxerunt in operum perfectiones. Et ea probaverunt, quorum explicationes, in disputationibus, rationem possunt habere veritatis."

IN one respect, this passage is extremely obscure, but, in another view, it is sufficiently clear to answer the present purpose. The obscurity arises from the difficulty, or rather impossibility, of discovering the meaning of several of the technical terms employed, these being very rarely used by authors, and relating to a mode of building different from any now practised. But, whilst commentators differ as to the precise meaning of the words *cantherius*, *asser*, and *templum*, as used in this passage, they all agree in considering them as denoting parts of the timber frame of a roof. At the same time, *mutulus* and *denticulus* are well known terms of architecture, and appropriated.

A FAINT and distant resemblance, however, of the original, has generally been found to answer all the end proposed by the imitation; a resemblance, which may sometimes be traced in the general distribution of the edifice, sometimes in its minute parts, and not unfrequently in both.

BUT the forms of nature, thus introduced, have been greatly modified by those of masonry. For though stone is by nature shapeless, yet, in the course of practice, many peculiar forms have been long established, and currently employed, in working it; such as straight lines, plain surfaces, square angles, and various mouldings used to soften the effect of abrupt terminations; all of which, originating in motives of mechanical convenience, and of simple ornament, had, in very early times, been appropriated to masonry, and considered as essential in every finished work of stone; so that, when the imitation of nature was introduced, these masonic forms still maintained their ground, and, being blended with the forms of nature, the two classes reciprocally modified each other.

THIS combination of art with nature, of which we see the most perfect example in the Corinthian capital, produces what are

appropriated to buildings of stone. The latter part, which relates to the principle of imitation in general, is sufficiently clear. The passage, in English, is nearly as follows:

"THUS, in the works of the Greeks, denticles were never placed under a modillion, because it is impossible that the *afferres* can be under the *cantherii*. If, then, what is situated over the *cantherii* and *templa in reality*, be exhibited as under them in the *imitation*, the principle on which the work proceeds is belied.

"IN the same manner, the ancients never approved of, or directed, the introduction of modillions or denticles in the frontispiece, but preferred a plain cornice; for this reason, that neither the *cantherii* nor *afferres* lie towards the gable, nor can they project beyond it, but are placed with an inclination to the gutter.

"THUS, they esteemed it a departure from principle to exhibit, in an imitation, what could not occur in reality. For in finishing their works, they introduced every ornament in an appropriated manner, and according to a real analogy borrowed from nature; and they approved of nothing, which could not be theoretically accounted for, on the principle of its resemblance to truth."

are called architectonic forms, in which the variety of nature, being subjected to the regularity of art, the work acquires that peculiar character, which, in a natural object, we consider as offensive, under the name of FORMALITY; but which, in architecture, we admire as a beauty, under the name of SYMMETRY: thus, we reprobate the formality of an avenue, and praise the symmetry of a colonnade.

SUCH is the nature of architectonic imitation; a device, which probably originated in accident, but to which architecture is indebted for its highest attainments.

I WAS first led by Mr BYRES, a very respectable member of this Society, to observe, among the remains of antiquity at Rome, many beautiful examples of the application of these principles by the ancients; and though my view of the subject was then very obscure, the theoretical solution of the question not having occurred till long after, I was fully aware of the very great practical advantages which they had derived from the employment of the principle of imitation.

OCCUPIED with this view of ancient art, as I was travelling through the western provinces of France, in my return from Italy, in the end of 1785, I was struck with the beauty of many Gothic edifices, which, far from appearing contemptible, after the masterpieces of art I had seen in Italy and Sicily, now pleased me more than ever. I was thus induced to believe, that those extensive works, possessed throughout of so peculiar a character, and so eminent for unity of style, could not have been carried on, unless the architects who built them, like those of ancient Greece, had been guided, in their execution, by some peculiar principle; and being dissatisfied with all the theories of the art which I had heard of, I undertook the investigation, which has given rise to the following Essay*.

b 2

CONCEIVING

* AFTER stating my own views at full length, I shall enumerate and examine the various opinions of others on the subject of Gothic architecture, no less than five

in.

CONCEIVING that some rustic building, differing widely from the Grecian original, might have suggested the Gothic forms, I had made it my business to search for such a one, when the following accidental circumstance greatly assisted my speculations.

It happened that the peasants of the country through which I was travelling were then employed in collecting and carrying home the long rods or poles which they make use of to support their vines, or to split into hoops; and these were to be seen, in every village, standing in bundles, or waving, partly loose, upon carts. It occurred to me, that a rustic dwelling might be constructed of such rods, bearing a resemblance to works of Gothic architecture, and from which the peculiar forms of that style might have been derived †. This conjecture was at first employed to account for the main parts of the structure, and for its general appearance only; but after an investigation carried on, at different intervals, during the course of these eleven years, with the assistance of some friends, both in the collection of materials, and in the solution of difficulties, I have been enabled

to

in number. At the time here alluded to, I was acquainted with an opinion, which I have since found to have originated with Dr WARBURTON, that the Gothic style was copied from an alley of trees. I was aware of the advantages of this theory in some essential points, yet it always appeared to me unsatisfactory in many others; and I conceive it to be at best far too vague to serve as a guide to the artist.

† THIS resemblance, though very obvious in many cases, has not, to my knowledge, been observed by any one but the late Mr GROSE; to whom it seems to have occurred in a transient way. He makes use of the shape of a bower to assist his description of a Gothic roof, (*Antiquities of England and Wales*, p. 75.); but he does not go so far as to ascribe the architectonic forms to this origin; a view, which probably, would not have escaped him, had he not been preoccupied with a different one; for he considers the rudiments of a Gothic arch as formed "of two flat stones with their tops inclined to each other, and touching." I did not meet with this passage till several years after I had undertaken the present inquiry, and had carried it a considerable length.

to reduce even the most intricate forms of this elaborate style to the same simple origin.

IN the present state of the question, the following inquiry must be considered as falling under the denomination of, what is called by Mr STEWART *, "*Theoretical History*," and by some French authors, "*Histoire raisonnée* ; being an attempt to trace, by conjecture, the steps through which an art has passed, in attaining the state in which we observe it. Indeed it is probable, that few investigations have been undertaken, which more completely correspond to that definition, since, in most subjects of this kind, many steps of the progress are known, and nothing is required but to fill up, by theory, the interval between them ; whereas, in the present case, as all direct testimony is wanting, and as no steps of the actual progress of the art have come to our knowledge, our opinions on the subject, hitherto, can only amount to presumptions, founded upon the correspondence of the theory with the monuments of the art now in existence ; and, the more numerous and complicated the cases are, in which this coincidence takes place, the greater probability there is in favour of the system.

BUT, though such be the actual situation of the inquiry, we may hope to see it, hereafter, assume a different form ; for, should the conjecture, brought forward in the following Essay, carry with it sufficient plausibility to excite a spirit of research among persons best qualified to pursue the subject, there is reason to expect, that discoveries may be made, of a literary or architectural nature, by which its truth or falsehood will be established beyond dispute.

WHAT has just been said will, it is hoped, serve as my apology for having advanced a system, which, strictly speaking, is founded on conjecture alone ; and, on the other hand, for having enumerated a multitude of particulars, many of which might

* BIOGRAPHICAL Account of Mr SMITH.

might justly be considered as superfluous, were the theory supported by direct testimony.

OF THE ELEMENTS OF GOTHIC ARCHITECTURE.

WHEN we enter a Gothic church, our attention is first attracted by a double row of clustered pillars, composed of an assemblage of long and slender shafts, which, reaching from the ground nearly to the summit, there separate and spread in all directions, forming the ribs or *groins* (as they are called) of a vaulted roof. In the meeting of these groins, and in the windows of the sides and ends, we see the form of the pointed arch, the principal characteristic of Gothic architecture.

SUCH buildings have, I conceive, been executed in imitation of a rustic dwelling, constructed in the following manner :

SUPPOSE a set of round posts, (Pl. I. fig. 1. & 5.), driven firmly into the ground in two opposite rows, the interval between the neighbouring posts in the same row being equal to that between the rows, and each post being raised above the ground to a height equal to three of those intervals.

THEN a set of long and flexible rods of willow, being applied to each post, (fig. 2. & 6.); let them be thrust into the ground at its base, and bound to it by two tyings, one near the ground, and another at two-thirds of its height ; the rods being left loose, from this last point upwards, and free to be moved in any direction. Let three rods be connected with each outside corner post, (as A or H of the ground-plan fig. 6.), and five with each

each of the others, (as B or G), and let their position be such as to cover the inside of the post, (as marked by little circles in fig. 6.), so that, when seen from between the rows, the lower part of each post shall be concealed from the view, and present the appearance of a bundle of rods, (fig. 2.).

THINGS being thus disposed, the skeleton of a thatched roof may be formed, by means of the loose ends of the rods. This is represented complete in Plate II. figure 15. & 16.; but the structure being rendered intricate, by the mixture of different sets of forms, I have, for the sake of distinctness, described each of them separately, and have represented them by separate drawings, with each of which a ground-plan is connected.

A ROD from one of the posts, being so bent as to meet a similar one from the post immediately opposite to it, in the middle of the space between them, let the two rods be made to cross each other, and let them be bound together at their crossing, (Pl. I. fig. 3.). Thus will be produced the exact form of the Gothic arch. The same being done with each pair of opposite posts, and a set of pointed arches being formed, let them be connected together by means of a straight pole, laid upon the forks of the crossing-rods, and bound to each of them, (fig. 7. & 11.).

THEN let a loose rod be brought from each of any two contiguous posts in the same row, so as to form a pointed arch, similar to that just described, and nearly of the same height. This being done with every two contiguous posts, (fig. 8. & 12.), and a new set of pointed arches being thus produced, standing opposite to each other in pairs, let each pair be bound by a horizontal pole lying on the opposite forks, and crossing the longitudinal pole, described above.

Two of the rods of each corner post, and three of those of each of the others, being thus disposed of, we have one of each corner post, and two of each middle post still to employ;

ploy; which is done as follows: A pair of these unoccupied rods being brought from any two posts which stand diagonally to each other, (A and F, fig. 6.), and made to meet in the middle, not as in the first case, crossing in an angle, but side by side, forming a semicircle, and joined together after the manner of a hoop, (fig. 4.); and the same being done with every pair of diagonal posts, (fig. 9. & 13.), the whole rods will have been employed.

EACH of the three sets of arches having thus been separately described, (fig. 7, 8, & 9.), the complete structure, in which they are all combined, may easily be understood, (Pl. I. fig. 10. and 14., and Pl. II. fig. 15, & 16.).

IN this manner a frame would be constructed, fit to support thatch or other covering, and such a one has probably been often used. It would seem, however, that, for the sake of strength, the number of rods has been increased in each cluster, by the introduction, between every two of them, of an additional rod, which, rising with them to the roof, still continues its middle position, as they spread asunder, and meets the horizontal pole at an intermediate point. This is shown in Plate III. figure 19, which is drawn with its covering of thatch; and the same is expressed in the corresponding ground-plan, figure 20.

FROM the imitation of a dwelling, so constructed, we may now trace the three leading characteristics of Gothic Architecture, the pointed arch, the clustered column, and the branching roof, (Pl. II. fig. 17, & 18., and Pl. III. fig. 21, & 22.)*.

THE

* IN buildings of stone, the arch or groin, which joins the diagonal piers, is very generally a real semicircle, like that in the willow structure just described; as I have found to be accurately the case at Beverley and Melrose. This rule of execution, with the deviations from it, which we meet with occasionally, will be fully considered in a subsequent part of the Essay; in which it will be shown, that in the usual roof, where the diagonal groin is a semicircle, it becomes the regulator of all the rest, determining their height and form in every respect.

THE rustic fabric might thus be covered completely, but would not be habitable, unless the openings of the sides and ends were closed, so as to resist the weather. This might easily be accomplished, by means of basket-work, covered, as is still practised in many countries, with a mixture of clay and straw. In order to furnish ribs for the basket-work, a set of upright rods would be thrust into the ground below, and bound to the arch above, dividing the opening into spaces reaching from top to bottom, (Pl. IV. fig. 23.), which, being filled up with twigs wattled through them, would be entirely closed, (fig. 24.), and the work would be tolerably strong. It might however be thought adviseable, for the sake of greater strength, to split all the upright rods, down to the level of the points at which the main rods of the opening separate from their respective posts; or, to borrow a term from architecture, down to the level of the imposts of the arch; and then to carry the half rods, so split, across the rest, in such a manner as to afford the opportunity of repeatedly binding them to each other, (fig. 25.).

BUT were the spaces all shut in this manner, the house would be rendered absolutely dark. It would therefore be necessary to provide for the admission of light, which might be done, without materially weakening the structure, by omitting some of the wattled work in the middle, so as to leave part of the ribs open and bare, (fig. 25.).

THESE naked ribs seem to have suggested the forms of the slender bars of stone, called Mullions, which constitute the framework of the glass, in all Gothic windows; the most common example of which may be seen in (fig. 27.).

THE window, in the fabric of stone, as well as in that of willow, being very conspicuous, would naturally become an object of attention in point of beauty. Accordingly we find, that, in the composition of Gothic edifices, much pains have been bestowed in ornamenting the windows, by the introduction

of a number of figures, which are often extremely elegant, and sometimes surprisingly complicated, though without confusion; for they can all be traced to some variety or modification of the simple elements just laid down; as will be shown, when we treat of the more complicated works of Gothic architecture; at present, it is necessary to mention only one other design.

IN this window, (fig. 26.), the halves of the neighbouring rods are brought to meet, but not to cross, and are bound together so as to touch each other, back to back; next, the halves of each rod being brought together again, they are bound face to face; then again separated, and bound a second time back to back, with the halves of the neighbouring rods; and so on, till the whole space is filled with a set of regular and equal compartments, bounded by waving lines, (fig. 26. & 29.).

THE form of the Gothic door may be traced to an origin similar to that of the last mentioned window. One pair of rods, (fig. 31.), being brought from the posts which form the upright sides of the door, are made to meet in a pointed arch, in the manner described above; then, another pair of rods, longer than the first, and connected with the same posts, are brought to meet above them, and are bound together face to face, like the half rods in the last mentioned window; the space between the two pairs of rods being occupied by a circular hoop.

THE representation of the upper pair of rods, when dressed with some small ornaments, as in many Gothic buildings, produces a most elegant effect. Figure 33. is a door of St Mary's, Beverley, reduced from a drawing taken on the spot, at my desire, by Mr J. HALFPENNY.

THE form of the steeple, however various and apparently different from what has hitherto been mentioned, can easily be reduced

duced to the same principles. The common steeple, or sharp pointed spire, seems to have for its origin simply eight long and straight poles thrust into the ground, one in each of the angles of an octagon; and so inclined, that they all meet in a point, directly over the centre of the base, and raised above it four or five of its diameters, the rods, thus placed, forming together a very acute octagonal pyramid, (fig. 34.). The original object of a structure of this kind would probably be mere ornament, as it is not calculated to answer any purpose we know of, unless it were to support a bell. Perhaps the first works of this kind, even those executed in stone, were placed upon the ground; but as a spire is seen to best advantage from a distance, an architect would naturally think of raising it in the air, by placing it on the summit of a tower; which is the case with all the spires of this kind I have seen. Figure 35. is a view of the spire of Tuxford in Nottinghamshire.

BESIDES the rectilineal spire, we sometimes meet with others of a curved form, which may be accounted for in a manner no less satisfactory, as shall be shewn in a subsequent part of this Essay.

HAVING now taken a view of all those parts of Gothic architecture, which constitute its solid mass, it remains, in order to complete the elements of the art, that we consider two sets of small ornaments, which very often occur, and which, though not necessary in theory, nor universally observed in practice, arise naturally from the principles already laid down, and contribute very much to give to Gothic architecture that peculiar appearance by which it is distinguished. Both these ornaments may be traced to the effects of time upon the materials employed in the construction of our rustic fabric; one set being connected with the vegetation of the rods, and the other with their death and consequent decay.

As it would frequently happen, that the willow rods, thrust into the ground, would strike root and grow, the architect seems to have taken advantage of this circumstance, by representing them as decorated with buds and tufts of leaves, whenever he thought that such ornaments could be introduced with good effect.

THIS practice has been very generally followed in the execution of the door, as in that exhibited in figure 33. the upper part of which is a representation of living rods, covered with tufts of leaves, like those in actual vegetation, (fig. 32.). Upon the spire, too, a set of small projections, placed at regular intervals, often occur, as in that of Bunny, in Nottinghamshire, (fig. 37.), which seem to be the representation of buds springing from the poles of the original, (fig. 36.).

THESE ornaments, known by the name of *Croquets*, when placed on the sloping part of doors, steeples, pinnacles, &c. and of *Finials*, where they form a tuft on their summit, universally and unequivocally represent foliage. The leaves, it must be owned, however, seldom resemble those of trees, but more commonly some plant of the cabbage kind. On this occasion, the artist has used the freedom to deviate from the strictness of the imitation, and has contented himself with adhering to the general idea of foliage. But, in so doing, he has been in a great measure justified by the circumstances of the case; for the foliage of a tree, especially that of the willow, being composed of a multitude of small and detached parts, could not, without much difficulty, be executed in stone, and would produce a very frail and perishable work, which could only be placed with advantage in very protected situations. He has thus been induced, in most cases, to choose some plant having a massy and compact form, better adapted to sculpture. This however is not without exception, as we do meet sometimes with croquets

kets formed of the leaves of various trees, especially of those of the vine; as may be seen in York-Minster in several places; particularly in that very interesting collection of pediments and pinnacles, surrounding the inside of the nave and its aisles. These are executed with amazing delicacy and elegance, and with such fertility of invention, that, though eighty-eight in number, not only every two of the pediments, but every two crockets on the same pediment, differ from each other*.

UPON

* ONE of these pediments, with its pinnacles, crockets, and finials, executed on a large scale, may be seen in that beautiful collection of the ornaments of York-Minster, now publishing in numbers by Mr HALFPENNY: in which work, likewise, are many other things applicable to the present subject. I am happy to have it in my power to bear testimony to the faithful accuracy with which the objects are there represented, from having examined several of the originals in that view, in the course of last summer, (1796), particularly that of Plate XLI. of which I made a drawing myself, in company with Mr HALFPENNY; so that I can vouch for its exactness in every respect. I have been induced thus particularly to mention the subject, by a suspicion mentioned in Mr HALFPENNY's seventh number, concerning the accuracy of his drawings; some gentlemen having imagined, that he had placed the sculpture in too advantageous a light. To this he answered, that "in truth he has not been able, "in many instances, to come up to the spirit and elegance of the originals." A declaration no less true than it is modest. I am well convinced that the gentlemen, with whom this suspicion has originated, have not been much accustomed to examine our Gothic buildings of eminence, since, in any of these, they would have met with numberless works, executed in too high a style of design to admit of embellishment in the present state of the arts. Nor is it wonderful that such should be the case, when we reflect, that they belong to the 14th and 15th centuries; during which, a series of artists flourished in Italy, who, in point of chaste design, and careful imitation of nature, have never since been equalled, though they had not attained to many of the refinements which were introduced in the subsequent age. These artists travelling over Europe, contributed greatly to the ornament of the Gothic edifices which were then building, as we learn from many curious facts collected by Lord ORFORD, in his *Anecdotes of Painters*.

I SHALL enter more fully into this subject, when I speak of the History of Gothic Architecture; and I am led to touch upon it now, though out of place, in order to call the attention of men of taste to the fate of numberless beautiful ornaments of

the

UPON the monument of King JOHN I. and Queen PHILIPPA, in the church of Batalha, are two canopies of frittered-work, constructed in a manner which I shall endeavour to explain in a subsequent part of this Essay. The lower part of each of them consists of an arch of contrary flexure, like that of the door of St Mary's, Beverley, (fig. 33.), but ornamented in a manner somewhat different, having, in place of the crockets, a set of leaves, in form and arrangement, greatly resembling those of the willow*.

WHOEVER the Gothic style, which are daily perishing by the exertions of a mistaken zeal in their favour.

EVERY year, great sums are bestowed in dressing up the old churches, in many parts of England, much to the detriment of these noble edifices. In some cases, this is done by besmearing the building with white or yellow paint, which chokes and confounds all the delicacy and elegance of the sculpture. This evil, however, is not of the deepest kind; since, here, the original forms of the work remain entire, and may be again restored to their purity, when a better taste prevails. But an injury of a much more serious nature is occasioned by the operation of chipping, in which the mason, with a barbarous hand, actually goes over the whole work, and chisels off the surface to a certain depth, leaving but a poor shadow of the original form. By both operations, the building acquires the harsh and glaring appearance of new work; which, however, is removed in a few years, by the influence of the weather, and the edifice recovers its former grandeur, as far as colour is concerned. But the havoc committed by chipping is quite irreparable; for the sculpture, when once removed, can return no more.

I HAVE been told, in vindication of this practice, that the forms of the old work were restored exactly as they originally stood. An idea worthy of the simplicity of MUMMIUS the Roman general, who demolished Corinth. As if it were in the power of every stone-cutter to replace a master-piece of the 15th century!

I WAS happy to find, at York, that a different spirit prevailed in the operations carrying on in the Minster. In all these repairs, the ancient sculpture has been most scrupulously respected; and, in many places, the stone has been carefully freed from its load of paint, so as to restore it to its original purity. For these attentions, the public is greatly indebted to the good taste and judgment of the Rev. Mr. EYRE, one of the residentiaries.

* SEE Mr MORPHY'S admirable publication; a work to which I shall have very often occasion to refer, when I speak of the more complicated forms of Gothic architecture.

WHOEVER pays any attention to Gothic architecture, must observe, in the upper part of most windows, an ornament projecting from the bars, formed by two curved lines meeting in a point. It would be difficult to describe this form in words, but it may be understood easily by figures 27, & 28. of Plate IV. which represent two contiguous windows of St Mary's, Beverley; in one of which the bars have been executed plain, and in the other they have been ornamented in this manner. Figure 30. is the window that lately stood in the chapel of Holyroodhouse at Edinburgh, and figure 29. the same general form executed quite plain, as it sometimes occurs. As this ornament has not, that I know of, been characterised by any peculiar name, I shall apply to it that of *culp*, by which mathematicians denote a figure of the same kind*.

It was long before any satisfactory explanation of this form occurred, though the frequency of its appearance, and the uniform manner in which it is introduced in all Gothic works, left little room to doubt that it had an origin, in common with the more substantial forms of the style. At last a friend suggested to me, that it may have been borrowed from the appearance assumed by the bark of the rods, when about to fall off, in consequence of decay. With this view, having attended particularly to branches in a similar situation, I have met with several facts, which tend to confirm this conjecture. The dead branches of every kind of tree, after being exposed to the weather during three or four years, throw off their bark, which, immediately before it drops, curls into various shapes, owing

* ASSEMBLAGES of these cusps are spoken of in the descriptions of Gothic works, by the names of trefoil, quadrefoil, semi-trefoil, &c. but no proper word has been used to describe the form, wherever it occurs, or however combined. This, I trust, will sufficiently apologise for the liberty I have taken, of introducing a new term into architecture.

AN application of the word *culp*, as used by mathematicians, may be seen in Dr SMITH's Optics, Vol. I. p. 172. where he uses it in describing the caustics formed by reflection.

owing to the unequal contraction of its different layers. This takes place variously in different woods; in some, the bark bends inwards, in some outwards, in some across the branch, and in some lengthways. I have had occasion to observe, that, universally, the bark of the willow bends concave outwards, and lengthways with respect to the branch. One of the first distinct examples I met with, of this kind, was on a rail at St Mary's Isle in Galloway, in the summer of 1792, (Pl. V. fig. 38.). The rail had been made entirely of fresh willow, and the posts had all struck root, having then the third year's growth upon them; the horizontal bars had died of course, and were in the act of losing their bark. This, in some places, was seen separated from the wood at one end, and adhering to it at the other, forming a gentle and continued curve with the mass of bark, which still remained attached to the wood; some pieces of bark, a few inches in length, had separated at both ends, and remained adhering only by the middle; in some places two contiguous pieces of rising bark met, and exhibited a shape very much resembling that of the cusped ornament which I have just described. In the summer of 1795, I saw, at the same place, a still more striking example of this, upon an upright post of willow, (fig. 40.), in which the two pieces of curling bark formed, together, a cusp from nine inches to a foot in length. In a few days, the under piece of bark fell off; but the upper one remained for more than a month, lying close to the wood during rain, and rising from it when the weather was dry. Figure 39. represents a large branch, which I cut from an old willow, having the curled bark upon it, and which, being kept dry, still retains its shape.

THERE is great reason to suppose, that this accident has suggested the cusped ornament: For if we suppose a window of the willow house, (fig. 41.), in the same state of decay with the rails just mentioned, to have come under the observation of an architect

test of genius, in the habit of borrowing all his ideas from a house of this kind, and eager to seize upon whatever contributed to add beauty or novelty to his work, it is natural to believe, that he would take advantage of the circumstance, by imitating, in stone, the curling bark; and this being executed with that regular symmetry, which architecture bestows upon the natural objects it represents, (fig. 42.), would produce a light and elegant effect, and the ornament would soon become general.

WE know that to such accidents, the architecture of the Greeks was indebted for many of its principal embellishments; of which the origin of the Corinthian capital is a striking and authentic example.

FINDING that all the essential parts of Gothic architecture could thus be explained, by tracing its origin to the imitation of a very simple rustic edifice, I was desirous of submitting the theory to a kind of experimental test, by endeavouring actually to construct a building such as has been described. With the help of a very ingenious country workman*, I began this in spring 1792, and completed it, in the course of the winter following, in a manner which far surpassed my expectation, and which has already met with the approbation of several Members of this Society. The method of construction answered so well in practice, that I doubt if a better could be followed, with such simple materials; and so primitive is the mode of execution, that I believe, with a little ingenuity, the whole might be executed without the help of a sharp instrument, or of any materials but such as the woods afford.

A SET of posts of ash, about three inches in diameter, were placed in two rows, four feet asunder, and at the interval of four
VOL. IV. *d* feet

* JOHN WHITE, cooper, in the village of Cockburnspath, in Berwickshire..

feet in the rows. Then a number of slender and tapering willow rods, ten feet in length, were applied to the posts, and formed in the manner already described, into a frame, which being covered with thatch, produced a very substantial roof, under which a person can walk with ease*.

THIS little structure exhibits, in miniature, all the characteristic features of the Gothic style. It is in the form of a Cross, with a Nave, a Choir, and a north and south Transept. The thatch, being so disposed on the frame, as not to hide the rods of which it is composed, they represent accurately the pointed and semicircular arches, and all the other peculiarities of a groined roof. The door is copied from that of Beverley. The windows are occupied by a number of designs, executed, (by means of split rods), in exact resemblance of those which actually occur in various Gothic edifices. Round each window is a border of compact wicker-work, which, by deepening the shade, adds greatly to the general effect. At a little distance stands the spire, formed of eight straight poles of willow planted in the earth, and rising in an octagonal pyramid to the height nearly of twenty feet. Various other Gothic forms are likewise introduced, which being of the more complicated kind, will be explained in a subsequent part of this Essay.

THE appearance of the whole, whether seen from within or from without, bears, I flatter myself, no small resemblance to a cathedral.

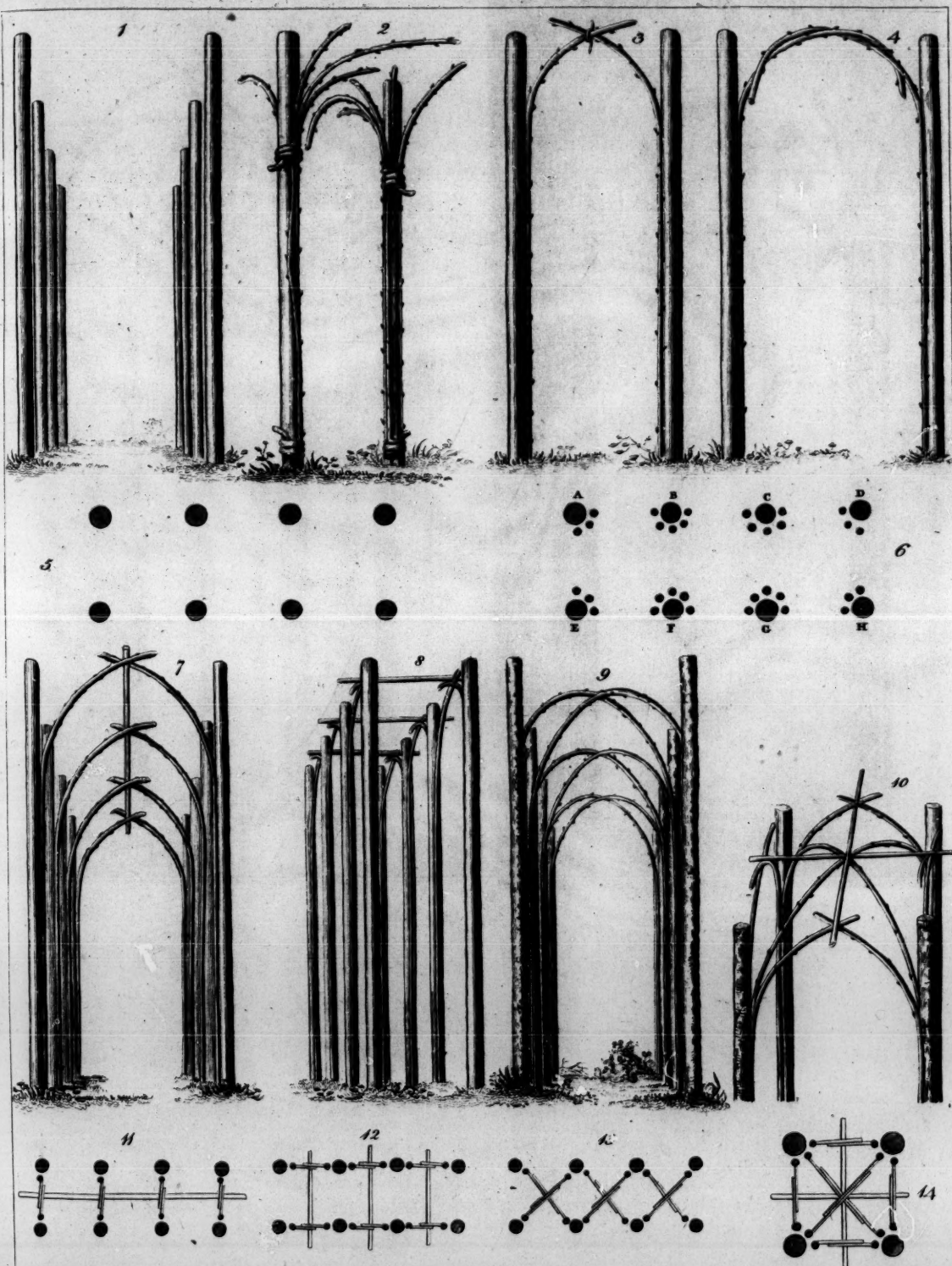
IN the course of spring and summer 1793, a great number of the rods struck root, and throve well. Those of the door, in particular,

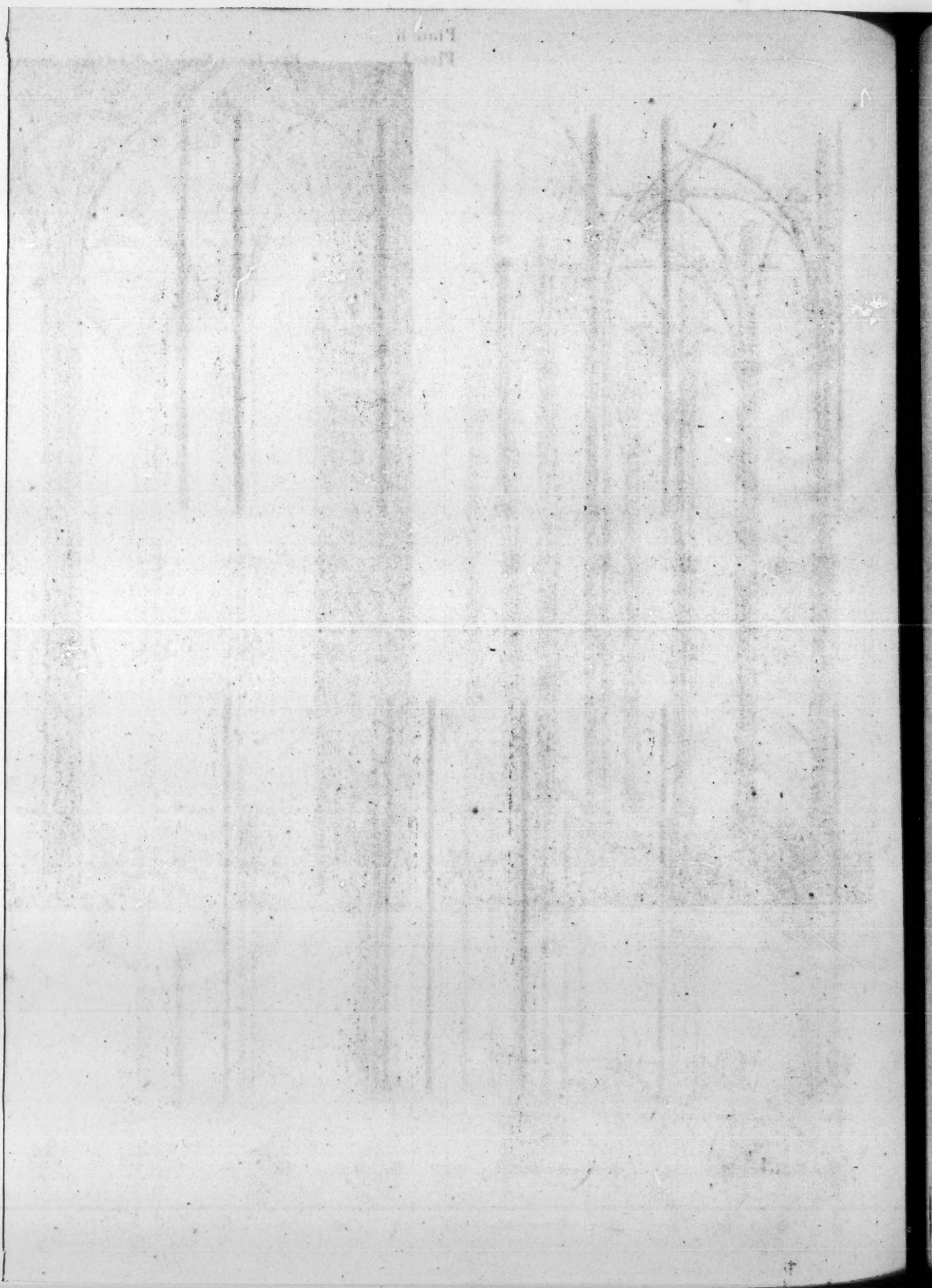
* THE roof, being protected from the weather, is still in perfect preservation, though it has now stood about five years; but the windows and other parts, which are more exposed, are going fast to decay, though they have been often repaired. Soon after the work was finished, a very accurate drawing of it was made by an ingenious young artist, Mr A. CARSE, which it is proposed to engrave for the illustration of this Essay, when published at full length.

particular, produced tufts of leaves along the bent part, exactly where they occur in stone-work; the vegetation did not however reach, as had been wished, to the very summit, but was more than sufficient to justify an artist in the execution of doors like that of Beverley, (fig. 33.). Three of the rods of the steeple, also, sent out buds, at small intervals, to the height of eight or ten feet from the ground, so as, at one stage of their growth, to resemble the budded spire already described.

I HAVE likewise had the satisfaction, in the course of last autumn, (1796), of finding one entire cusp formed by the bark in a state of decay, in a place corresponding exactly to those we see executed in Gothic works.

IN this manner, all the original forms of Gothic architecture may be accounted for. But they seldom occur in the state of simplicity, which, in order to facilitate their description, I have hitherto supposed; for, in a Gothic edifice, they are for the most part complicated by varieties in execution, and by intermixture with each other. They have been modified, likewise, and sometimes disguised, by the circumstances attending the transition from wicker-work to masonry, which have occasioned changes, both in the general design of these works and in the execution of their minute details. I shall endeavour to show, however, (in the work I have already announced), by an examination of the actual monuments of the art, that the most intricate of these forms may be traced to the same simple original. But to accomplish this, it will be necessary previously to investigate the transition to Masonry; an inquiry too extensive to be comprised within the limits of an academical memoir.



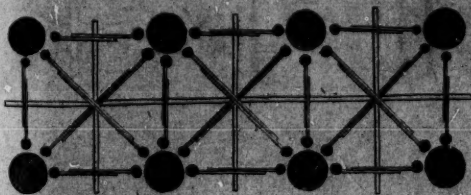




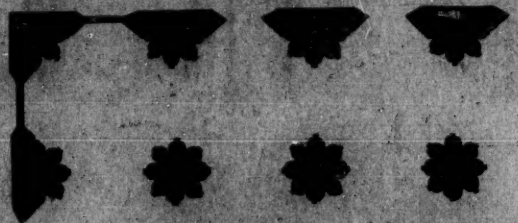
15



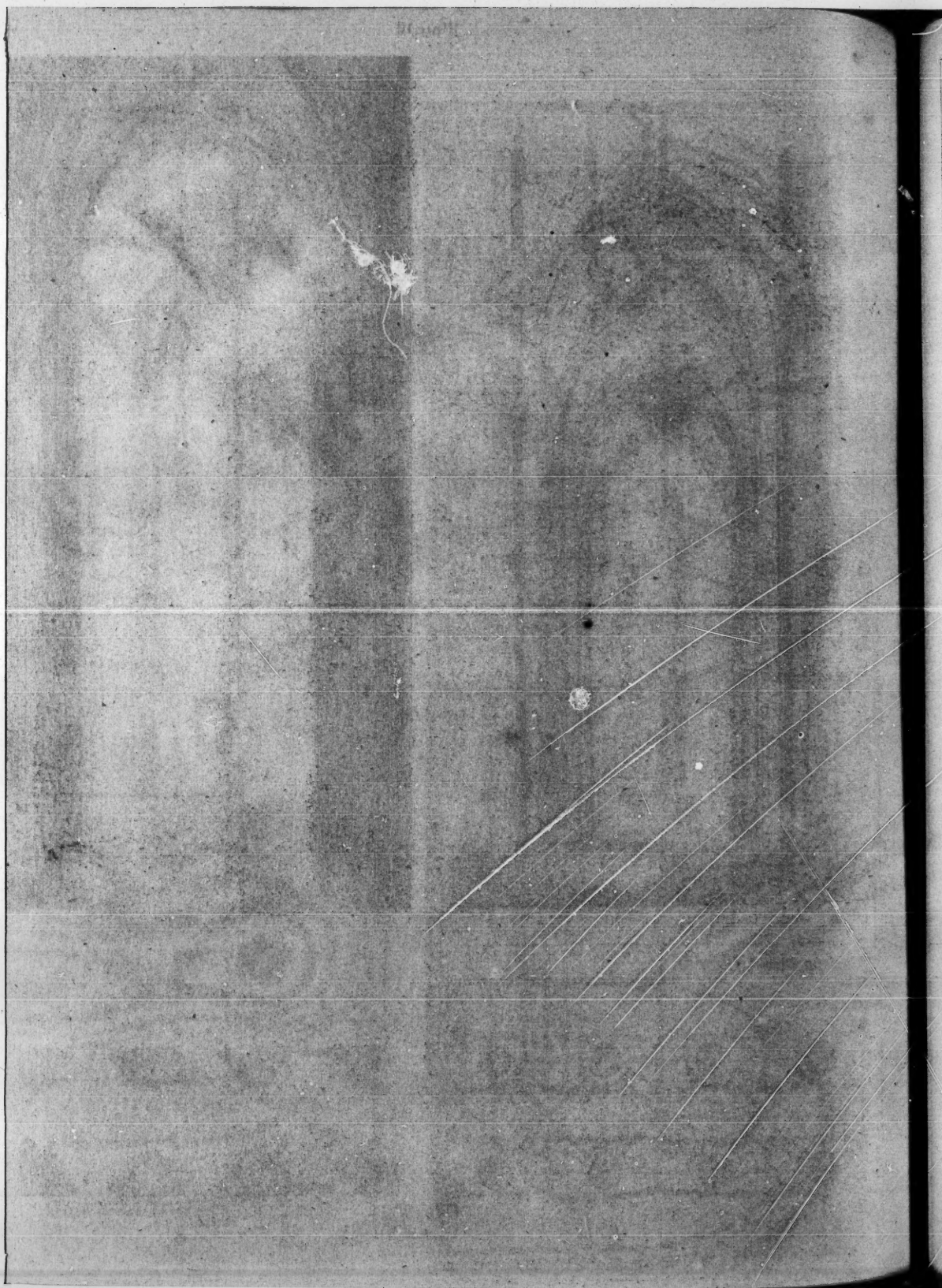
17

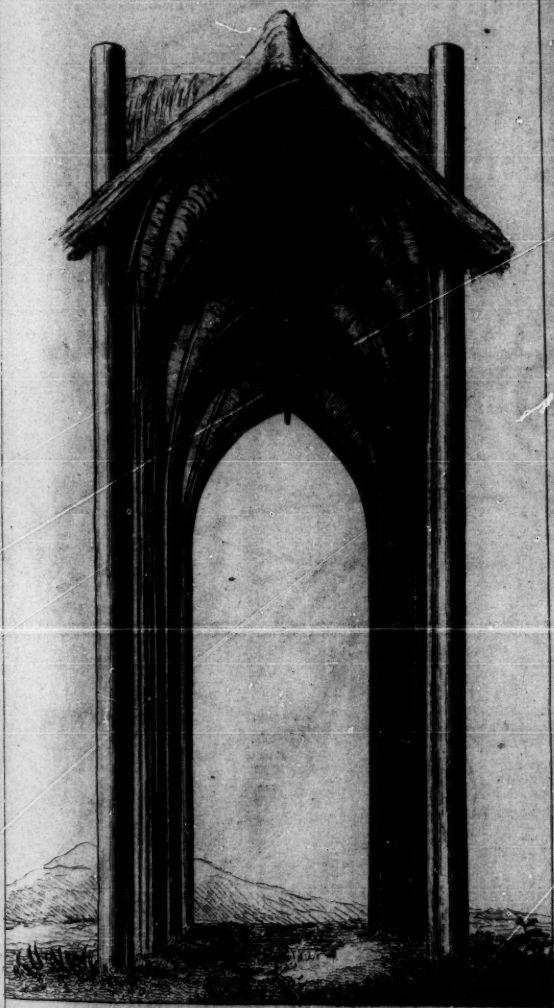


16

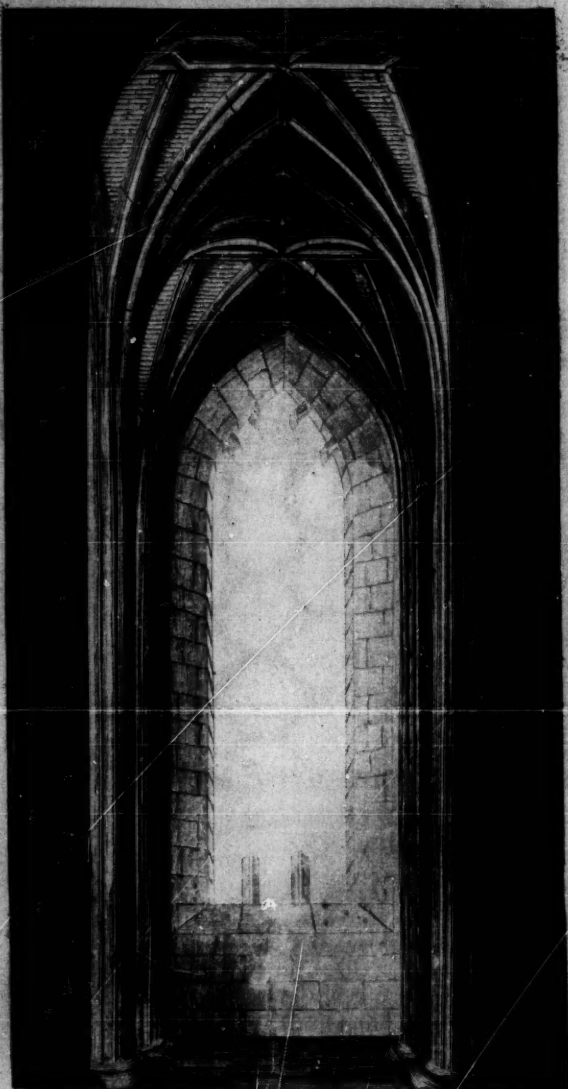


18

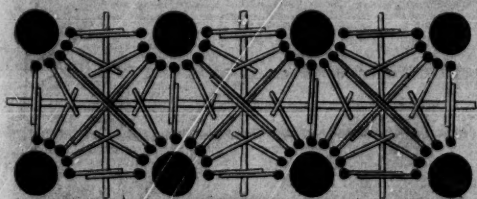




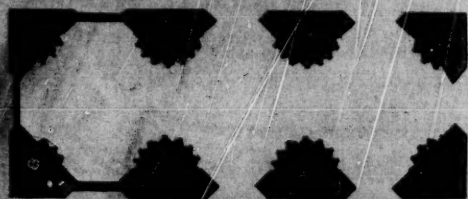
19



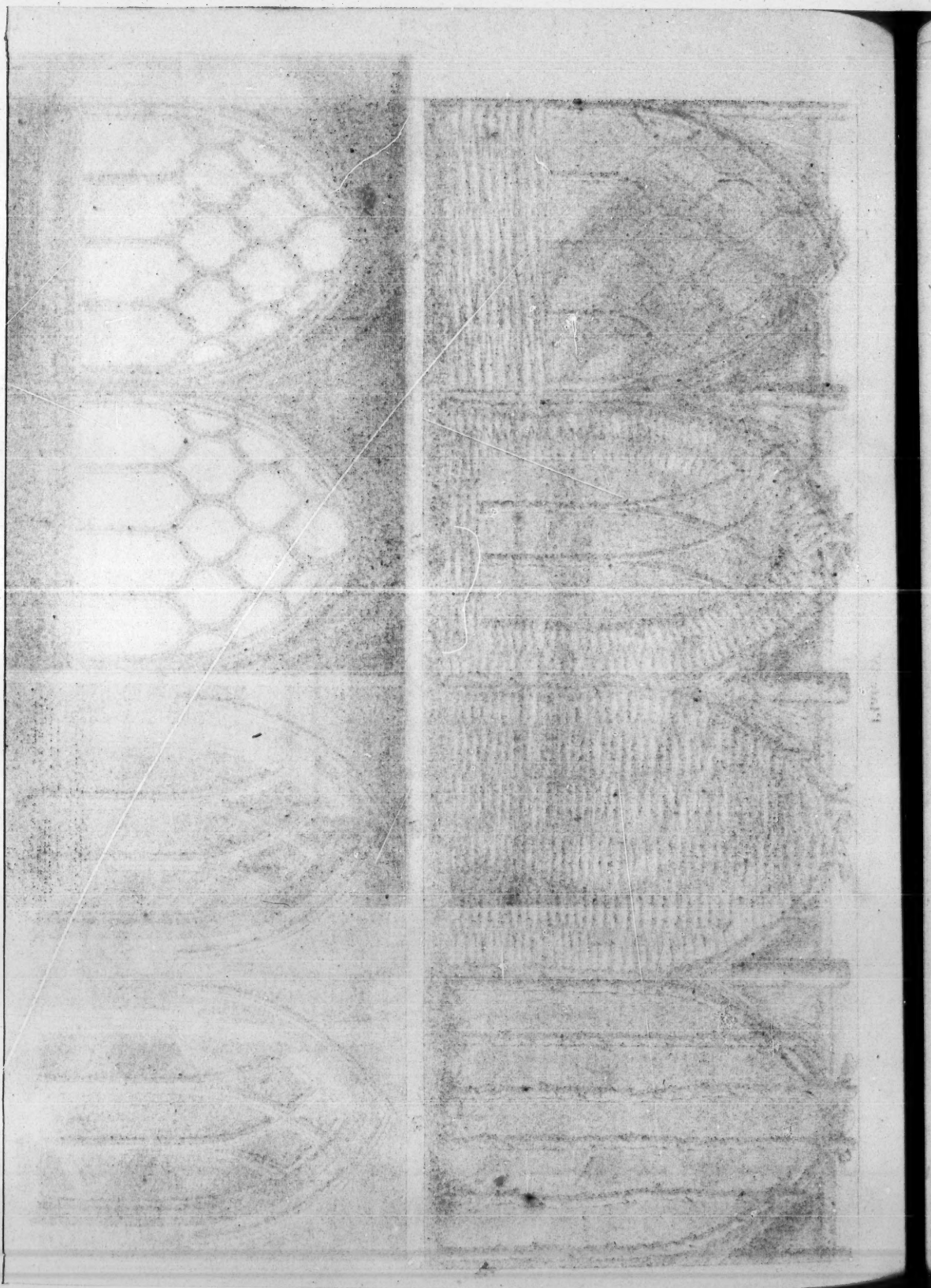
21

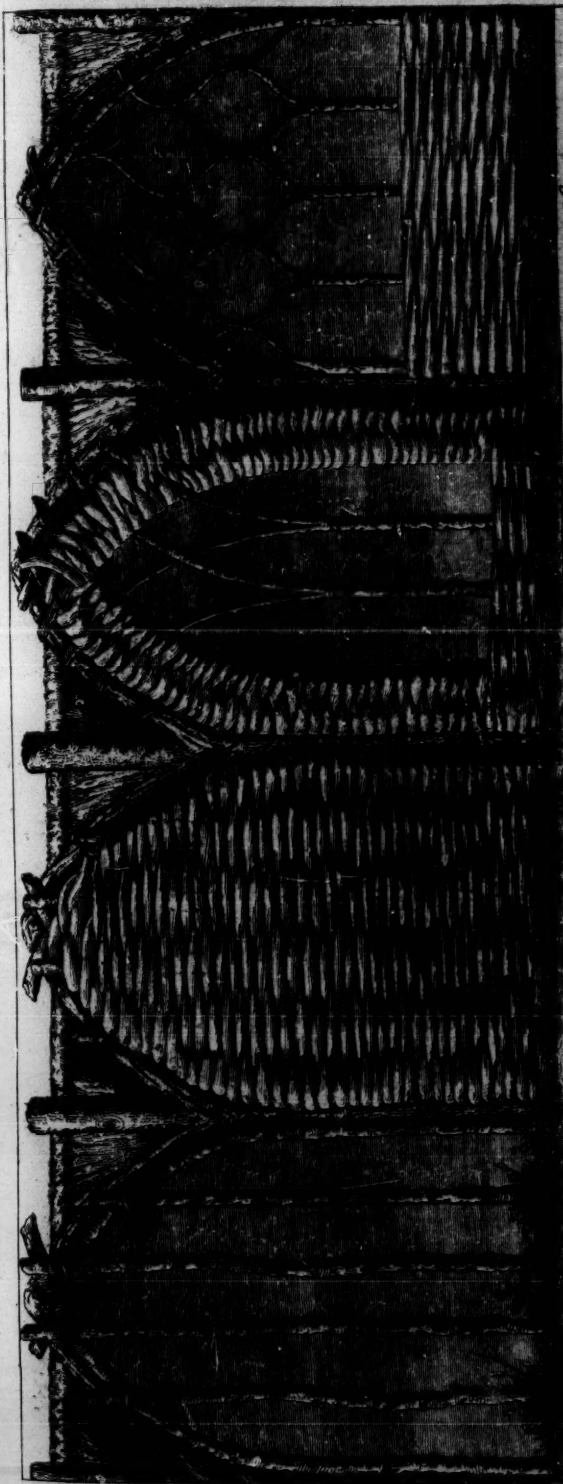


20



22





23

24

25

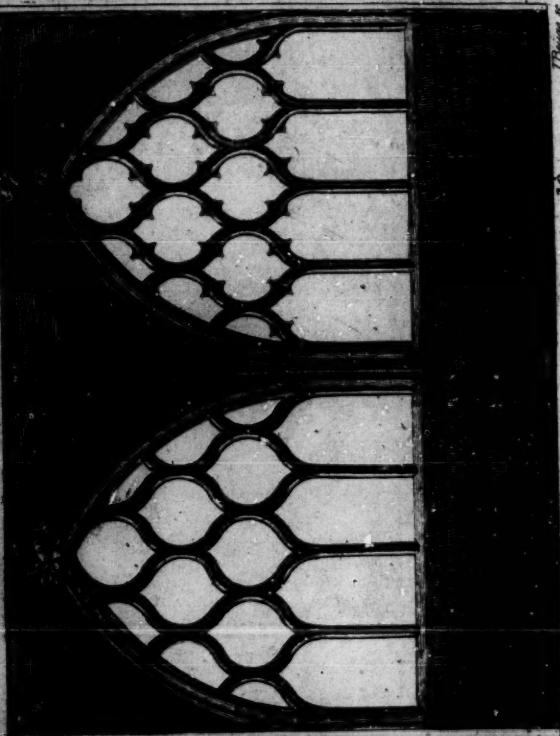
26



Sir J. H. del.

27

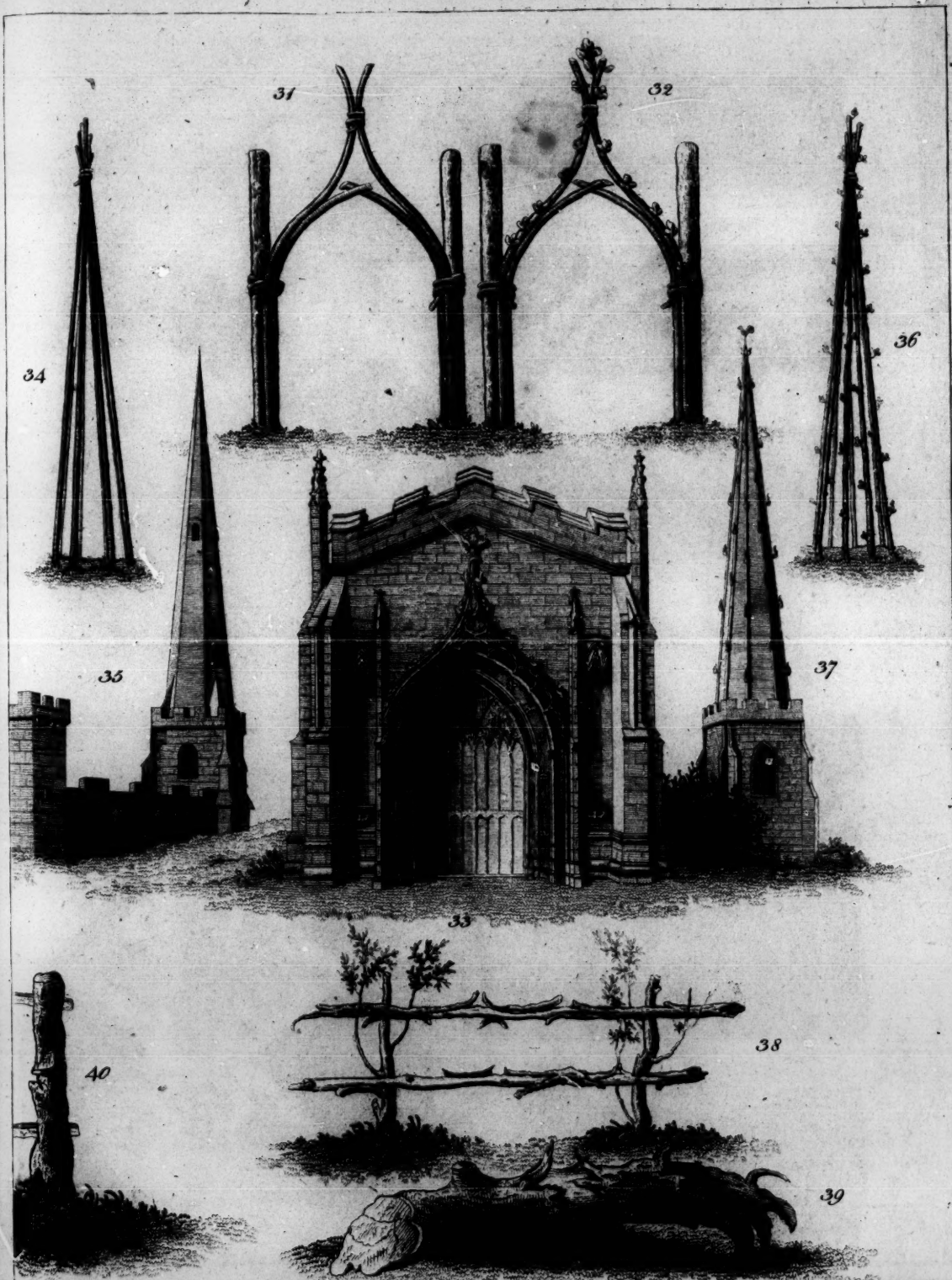
28

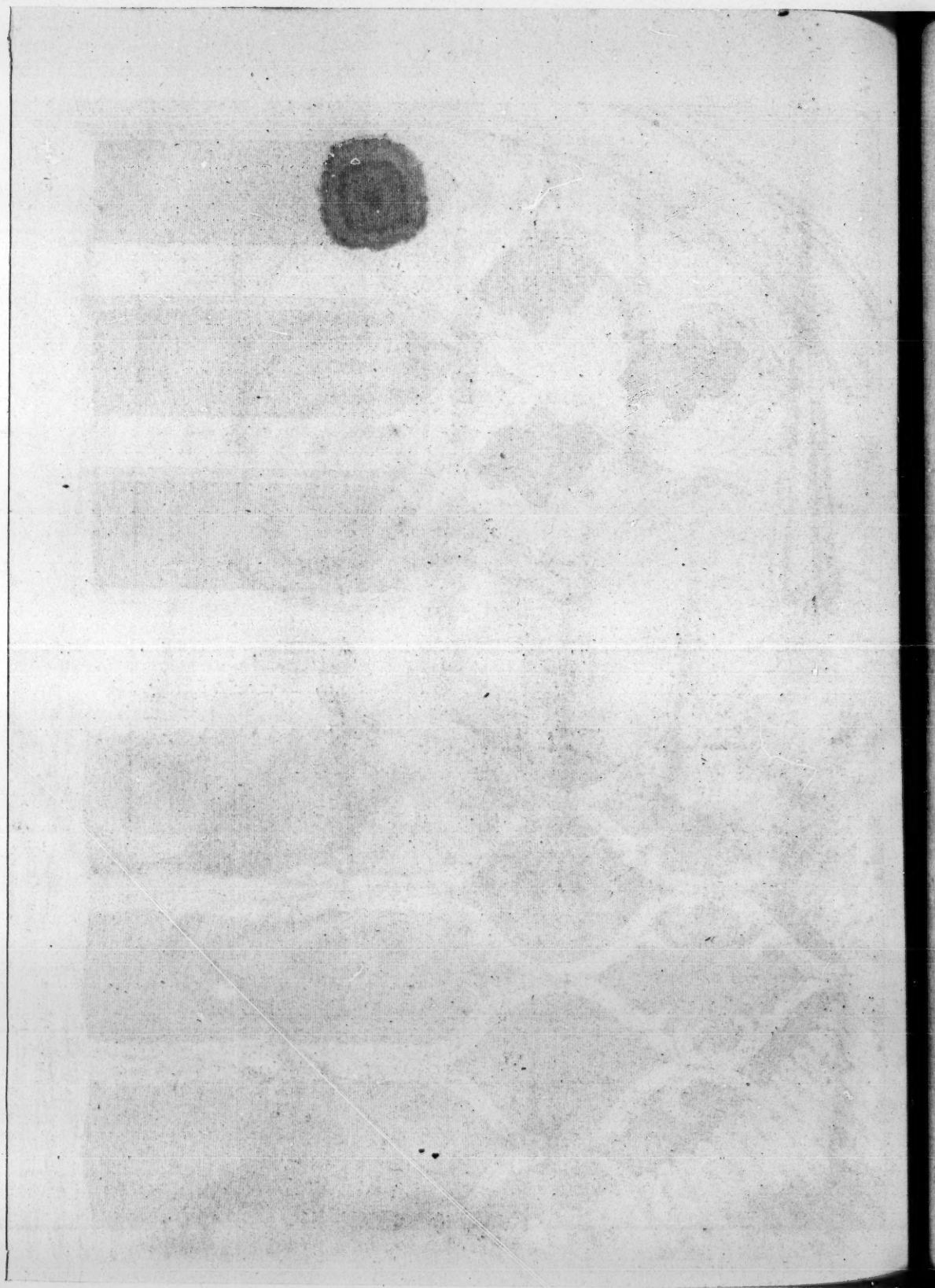


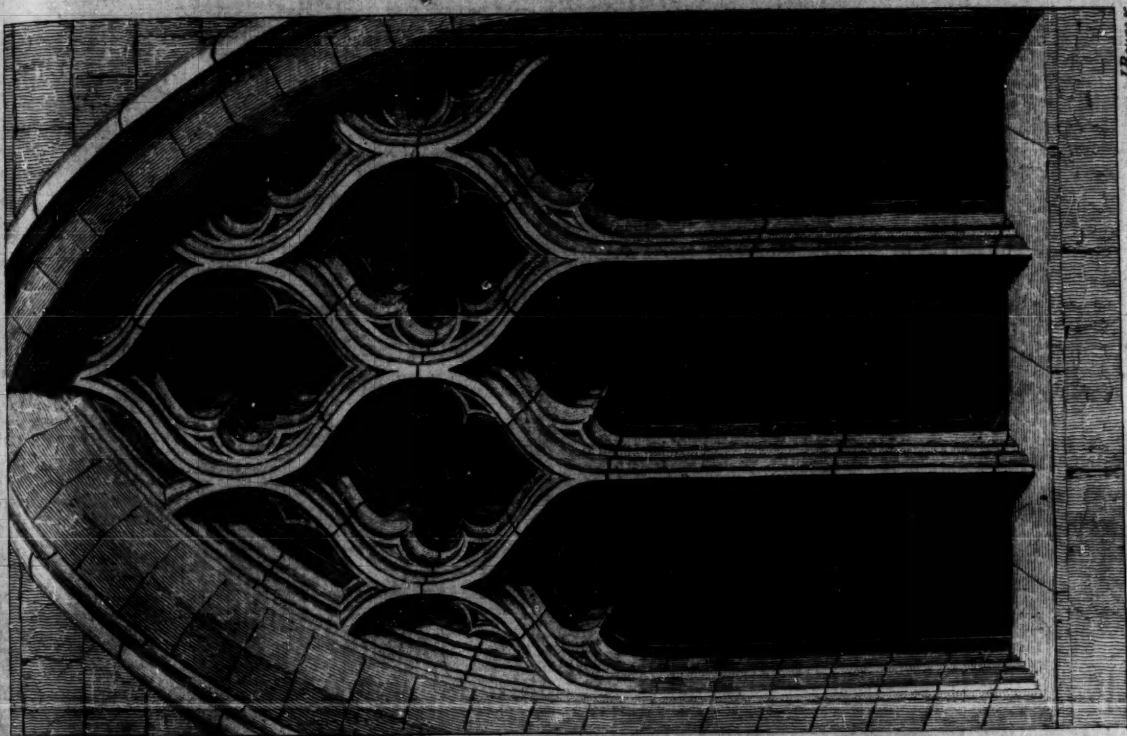
29

30

Designs by

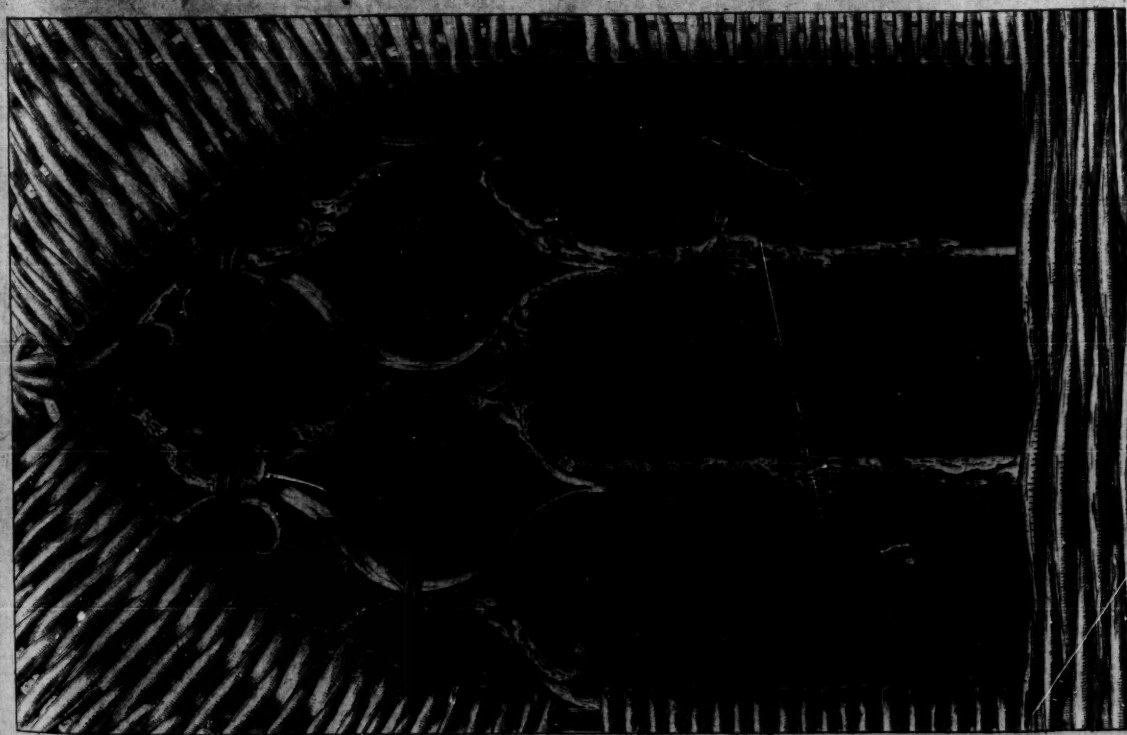






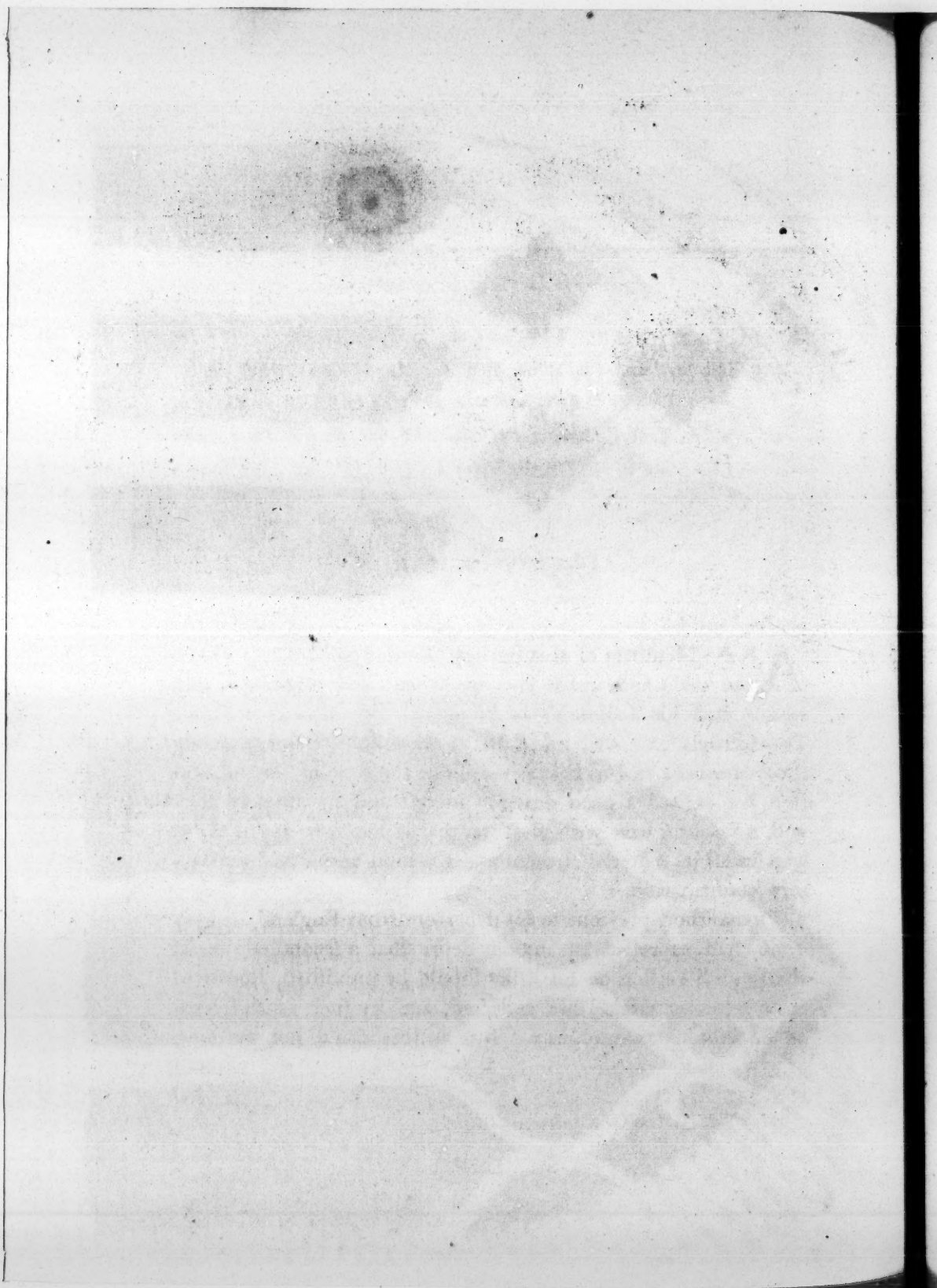
I. B. G. x

42



S. H. del

41



II. *M. CHEVALIER'S TABLEAU de la PLAINE de TROYE illustrated and confirmed, from the OBSERVATIONS of subsequent TRAVELLERS, and others.* By *ANDREW DALZEL*,
M. A. F. R. S. EDIN. *Professor of Greek, and Secretary and Librarian in the University of Edinburgh.*

[Read Sept. 4. 1797.]

AS the Members of this Society afforded to M. CHEVALIER an early and warm encouragement and patronage, and readily gave his *Tableau de la Plaine de Troye* a place in their Transactions*, as well as admitted the author to a seat among their number; and as that paper, since the time of its publication, has excited a good deal of interest and speculation, they will, no doubt, hear with pleasure, that it has now received, at least in all its material circumstances, a most ample and satisfactory confirmation.

THE author, previous to his departure from England, in May 1796, had expressed an anxious desire that a second edition of the English version of his Essay should be published, improved from some materials I had collected, and by such amendments as he should communicate. But as this could not be done, without

* See Vol. III. Lit. Cl. p. 1, &c.

without a new arrangement with the booksellers, and as an obstacle occurred which rendered a delay necessary, I have thought that it would, in the mean time, be agreeable to the Society to have a short Abstract of the most material contents of the Essay, as now confirmed by subsequent travellers, laid before them, preceded by an account of the manner of its first reception, of the communications of those travellers, and of certain objections that have been made to it; and followed by an Appendix, containing the papers and letters referred to in the foregoing detail.

Account of the Reception which the Description of the Plain of Troy at first met with.

M. CHEVALIER, after his return from the East, and before he came to Edinburgh, visited Paris, where he found the late M. l'Abbé BARTHELEMY, author of the *Travels of the Young Anacharsis*, to whom he gave some account of his excursions into the Troad. That celebrated and respectable scholar was so much pleased with the light he received, on this occasion, concerning that famous classical region, that he introduced M. CHEVALIER to a party of his friends by the title of *le Restaurateur de la Troade*: and it is probable that, if he had been favoured with M. CHEVALIER's information previous to the publication of his great work, he would have embellished his book with a more satisfactory description of the Troad, than he found himself able to do from the imperfect and inaccurate accounts formerly given of it.

In the year 1792, when the Dissertation in question, which the author had read in French before this Society, was published in the English translation of it, which, at his own desire, and with the approbation of the Council of the Society, I had made, it seemed to give great satisfaction to classical readers in general.

ral. In Germany, even before it was published, it had found a warm supporter in the celebrated Professor HEYNE of Gottingen, with whom the author became acquainted, in a tour he made in that country, soon after he had read the original of his paper in the meetings of this Society. Having no copy along with him, when he went into Germany, he endeavoured to give Mr HEYNE an idea of his researches in the Troad, as distinctly as he could from recollection, aided by some travelling journals which he had retained in his custody. He found the subject extremely interesting to Mr HEYNE, whose attention had been for some time particularly turned to the poems of HOMER, of which he had projected a new edition upon the plan of his Virgil, so favourably received by the Public. At the united desire of the author and Mr HEYNE, with the approbation of the Council of this Society, I first transmitted a printed copy of the translation, with notes, to Gottingen, before the work could be published here, and afterwards a copy of the maps, immediately upon their being finished by the engraver.

Mr HEYNE was highly gratified with M. CHEVALIER's discoveries, and pleased with what he considered as the very liberal manner in which they had been conveyed to him. That his countrymen might partake of the satisfaction he had received, he employed Mr DORNEDDAN, a young promising scholar, to translate into German the *Description of the Plain of Troy* from the English version. The greatest part of the notes, which I had subjoined, were also translated by the same ingenious scholar; a preface and further illustrations by Mr HEYNE himself, with an Essay on the Topography of the Iliad, and a Dissertation by Mr KAESTNER on the Height and Shadow of Mount Athos, were added; and the whole published in Germany in an octavo volume, almost as soon as the English version, with notes, appeared in England*.

* See Appendix, No. I.

It had been perused also, before publication, by several gentlemen of learning and taste in this place, who had desired to see it; some of whom expressed their satisfaction in conversation, and others in writing: and, after publication, I received letters from several eminent classical scholars in England, by whom M. CHEVALIER's labours were highly approved of. Some of these testimonies I have happened to preserve*.

BUT though M. CHEVALIER's researches, thus given to the public in English and in German, and afterwards in the French original in the third volume of the Transactions of this Society, were received in the most favourable manner by classical scholars in general; yet some, who had long before acquiesced in the account of the present appearance of this classical region given by the late Mr WOOD, could not conceive how that ingenious observer should have gone so completely astray on the ground as had been alleged; and were disposed to think, that an enthusiastic admiration of HOMER, common to M. CHEVALIER with many persons of sensibility and taste, might have presented to his fancy circumstances, and scenes and appearances, of which a cool and unbiassed examiner might not have perceived the reality.

Of the Communications of subsequent Travellers, and of certain Objections that have been made.

I HAD reason, therefore, to consider it as a fortunate circumstance, that, towards the end of the year 1793, Mr ROBERT LISTON, my own most intimate friend ever since a very early period

* IN a card from Mr HOME, author of *Douglas*, &c. (who still takes great delight in studying his favourite poet HOMER, particularly the *Odyssey*), I find the following expression: "I have read over your translation of M. CHEVALIER's Discourse, "which is the most satisfactory investigation and criticism I ever read." See Appendix, No. IV.

period of life, was, after being employed in various honourable public missions, appointed by his Majesty Ambassador to the Sublime Porte. Having the pleasure of meeting with him previous to his departure for Constantinople, I requested that he would endeavour to find an opportunity of paying a visit to the Troad, with M. CHEVALIER's book in his hand. This I found to be already his own inclination, as he still retained a fondness for classical learning, in which he had greatly distinguished himself, when a student formerly at this University. I only regretted that my own situation rendered it impracticable for me to accept of a most kind and tempting invitation to be the companion of his voyage. In the course of our correspondence, after he had been some time at Constantinople, I had the satisfaction to receive from him a short letter, inclosing two others from Dr SIBTHORPE and Mr HAWKINS, written immediately after an excursion they had made to the plain of Troy, and confirming the principal circumstances of M. CHEVALIER's discoveries. He afterwards transmitted extracts from another letter of Mr HAWKINS relative to the same subject, to all of which I shall have occasion to refer*.

IN the beginning of last year Mr BRYANT published his *Observations upon a Treatise entitled, A Description of the Plain of Troy, by M. CHEVALIER*, of which he did me the honour to send me a copy, accompanied with a letter. It appeared that this learned gentleman had, antecedently to the publication of M. CHEVALIER's Essay, been engaged in the composition of a *Dissertation concerning the War of Troy, and the Expedition of the Grecians, as described by HOMER, shewing that no such Expedition was ever undertaken, and that no such City of Phrygia existed*: but finding that the new *Description of the Plain of Troy*, by gaining credit in the world, might be likely to prevent the success of his learned labours, he deemed it advisable to employ his ta-

VOL. IV.

c

lents

* See Appendix, No. V.

lents in an attempt to invalidate and remove this obstruction, in order to pave the way for his *Dissertation*; which now at length has likewise made its appearance, and of which I have also received a copy from the learned author.

I AM now ready to admit (as, in a short correspondence with Mr BRYANT, on the first glance of the former of these productions, I promised to do, if afterwards, upon a careful perusal of that pamphlet, I should see good cause), that he has discovered what now appear to me to be inaccuracies and inadvertencies in several parts of M. CHEVALIER's performance, and some errors in the notes which I had written. For, upon topics and investigations, where hypothesis must sometimes take place, and where arguments may not always be conclusive, it is not to be wondered at if a person of Mr BRYANT's learning and sagacity should have detected a few improprieties and inaccuracies. But after a careful perusal, which I have now given both to his *Observations*, and his *Dissertation*, I cannot bring myself to go along with him in his views of this subject; nor can I be persuaded, by any thing Mr BRYANT has written, to give up the pleasure received from remarking the striking similarity between those scenes, which still exist, and the descriptions which occur in the poems of HOMER. This similarity has been traced by Mr HEYNE, in a most convincing manner, in his *Essay on the Topography of the Iliad*; a valuable piece of investigation, which of itself appears to me completely to refute all Mr BRYANT's radical objections to M. CHEVALIER's Essay*. I shall therefore decline following the learned gentleman through the minute parts of his elaborate performances, which indeed I want time as well as inclination to do: but shall content myself with introducing a few remarks upon his *Observations*. I most readily resign every attempt at framing an answer to his *Dissertation*; as I find he has met with two antagonists much better qualified to enter the lists with him

* See Appendix, No. III.

him than I am, the acute and ingenious Mr WAKEFIELD *, and a learned anonymous reviewer in the *British Critic* †.

MR LISTON being to return from his embassy at the Porte, towards the conclusion of the year 1795, I was glad to find, by a short letter, that he himself had made an excursion to the Troad; and understanding that a new edition of M. CHEVALIER's Essay was projected, he desired it might be deferred till he should come home, as he had some observations to communicate which would render the work more perfect. When I met with him at Edinburgh he was very much hurried, owing to his being under the necessity of setting off soon for America, as his Majesty's Plenipotentiary to the United States. He nevertheless devoted a few hours to the revival of M. CHEVALIER's Essay, whilst I sat by him and took notes of his remarks. As a great many of these consisted of small alterations of various parts of M. CHEVALIER's descriptions, with a view to condense them where they seemed too diffuse, and to correct them where they seemed inaccurate, it would be tedious at present to enter into a particular detail. But, in the case of a new edition of the Essay, I am persuaded that they would be extremely useful. It may be sufficient, here in this Introduction, to say in general, that Mr LISTON confirmed, from his own inspection, all the great points of M. CHEVALIER's researches and discoveries, after spending many hours in walking over the ground. He saw the supposed site of Ancient Troy, the sources of the Scamander, and the place where that river is now diverted into its new channel. In short, I found that Mr LISTON, along with a great desire to render every thing as exact and accurate as possible, had also caught that sort of interest in the subject, which is so natural

* See "A Letter to JACOB BRYANT, Esq; concerning his Dissertation on the "War of Troy: by GILBERT WAKEFIELD, B. A. Lond. 1797. 26 pp. 4to.

† For May and June 1797, vol. ix.

natural to a classical mind, when engaged in surveying or describing such pleasing scenes.

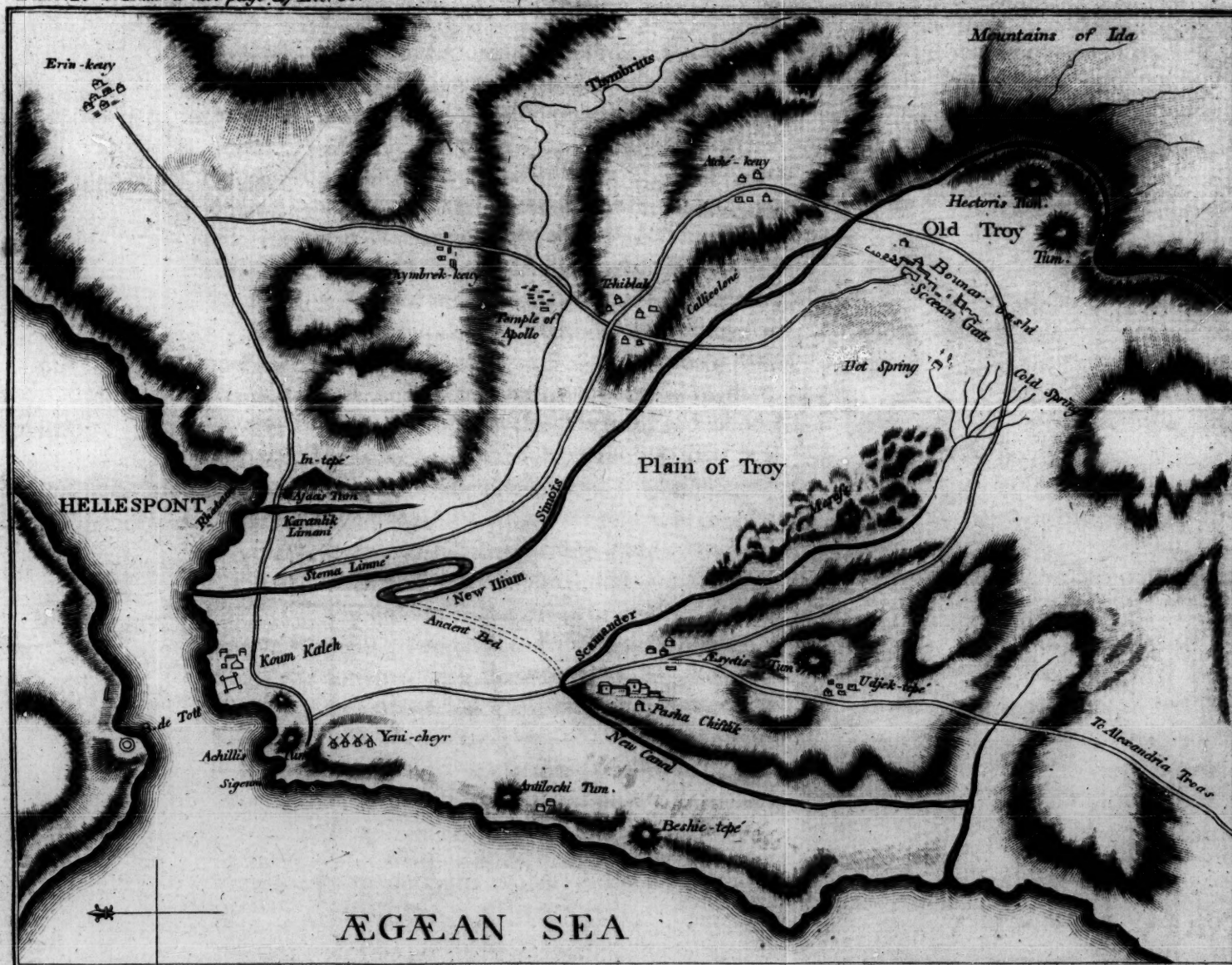
IN some parts of M. CHEVALIER's map, also, he found some inaccuracies, which he was enabled to rectify, both from his own observation, and from another map with which he had been furnished. This last he expected to be sent after him from Constantinople, and intended it should contribute to the improvement of M. CHEVALIER's in the new edition of the Essay*. Of all this I apprized M. CHEVALIER, in a letter directed to him in London, which found him about to set off for the Continent. Previous to his departure, I received from him two letters in answer; extracts from which will be found in the Appendix †.

BUT one of the chief inducements for bringing the subject before the Society at this time, is the recent publication of a very ingenious work, entitled, *Constantinople, Ancient and Modern, with Excursions to the Shores and Islands of the Archipelago, and to the Troad*. By JAMES DALLAWAY, M. B. F. S. A. late Chaplain and Physician of the British Embassy to the Porte. This learned author has been at great pains in ascertaining the topography of the Troad; and the result of his investigations there has produced the fullest confirmation of all the material parts of M. CHEVALIER's Essay, and a total but respectful dissent on the part of the author from Mr BRYANT's scepticism on this subject. To this book, therefore, I shall, in the ensuing paper, have frequent occasion to appeal.

ABSTRACT

* THIS map I have never received, owing to some omission which I cannot explain. In the mean time, this paper is accompanied with a small one, somewhat amended, chiefly from that given by Dr DALLAWAY, the author of the book presently to be mentioned.

† No. VI.



TOPOGRAPHICAL SKETCH of the PLAIN of TROY.



Scale of Miles
0 1 2 3 4 5 6 7 8 9 10

Fig. of TROJ

ABSTRACT of the most material Parts of M. CHEVALIER'S Essay, with the Confirmation of subsequent Travellers.

IN giving a short Abstract of M. CHEVALIER'S investigations I shall not follow the order in which he himself proceeded, but that which seems to convey the clearest idea of his discoveries and observations, now that they have been made. For the case is quite different with a person, who gives a detail of the manner in which he himself advanced in the course of investigating objects, of which he had at first but an imperfect notion, where the direct path leading to them was yet obscure and unknown, and where he had to form conjectures that were sometimes erroneous; and with one who points out or elucidates such objects after they have been discovered, and their relative situations ascertained.

AFTER M. CHEVALIER had formed the resolution of exploring the Asiatic coast, where the Hellespont unites with the Aegean Sea, with a view to ascertain the true topography of the Iliad, he happened to land first at *Cape Baba*, the ancient promontory of *Lectos*. Thence he proceeded to *Alexandria Troas*, the ruins of which he examined, and has given an account of; and this account Mr LISTON in conversation, and Dr DALLAWAY in his book, (p. 326.), have agreed in confirming; but of which a particular detail would be here unnecessary*.

The
* THE Turkish name *Eski Stamboul*; the warm baths called *Lidga Hamam*; the hill on whose declivity these are situated, and which is covered with tombs, whose sarcophagi of white marble the Turks break down and make bullets of, for supplying

The Plain.

IN advancing from Alexandria Troas, along the coast, M. CHEVALIER's attention was particularly attracted by a *tumulus*, or barrow of immense size, at a considerable distance*. This is now called *Udjek Tepe*, from *Udjek*, the name of the adjacent village. From the top of this at noon, (Ch. III.), he took a retrospect of the ruins of Alexandria, now at the distance of more than four leagues; towards the north he saw a large plain, encompassed with delightful hills; to the east the foot of the mountains of Ida; and to the west the *Ægean Sea*, the islands of *Tenedos*, *Imbros*, *Samothrace*, *Lemnos*, and all the way to the summit of *Mount Athos*.

DR DALLAWAY remarks, that "from the high ground near "Alexandria Troas, the view of *Tenedos*, and of the sea, with " *Udjek Tepe*, a vast *tumulus* above the plain of *Troy*, on the "right under the horizontal line, is particularly pleasing." (p. 326.). And that "in the progress the country soon becomes less woody, and spreads into a wide heath, from whence "the whole plain of *Troy* is seen."

WHEN M. CHEVALIER, in the course of his investigation, arrived at the eastern extremity of this extensive plain, on the eminence above the modern Turkish village called *Bounar-bashi*, and where he at last concluded the citadel of ancient *Troy* to have been placed, he obtained a view of the whole extent of it; and it seemed to him of a semicircular shape†. "Of the two chains

ing the Castles of the *Dardanelles*; the aqueduct of *HERODES ATTICUS*; the circuit of the wall still almost entire; the thickets of *Valonea* trees; are all likewise remarked by DR DALLAWAY, or were mentioned to me by MR LISTON. The former observes, that "the whole site is now a thick forest of *Valonea*, or dwarf oak, "peculiar to the Levant." Of this shrub the latter brought away some seeds.

* See the Map.

† Mr LISTON adds, "on each side."

"of hills which embrace it, one appeared to run in a direction "towards the promontory of *Yeni-cheybr*," (or Sigeum), "and "the other towards the point of *ʒn-Tepé-Gheulu*," (or Rhœteum). The part of the hills to the right, reaching between the villages of *Atché* and *Tchiblac*, appeared more cheerful than the rest, and which he had no doubt composed the Callicoloné of HOMER. From this station he descried "the islands of Tenedos and Imbros, Samothrace and Lemnos, the high top of "Mount Athos, and the Thracian Chersonesus beyond the Hellespont." (Ch. IV.). As to the soil of the plain, he observed it to be "of a rich and blackish colour, and of great fertility." The village of *Bounar-basbi* he reckoned to be "at the distance "of four leagues from the sea." (Ch. XVII.).

MR HAWKINS and DR SIBTHORPE took horses at *Koum-kaleb* on the coast, and crossed the plain to the village of *Bounar-basbi*, in three hours, "an extent," says DR SIBTHORPE, "of nine "miles*." MR HAWKINS, in his second letter to MR LISTON, assures him that Tenedos is to be seen from the hill of Troy, and that even "the whole coast of the island is visible, from the "northern to the southern point."

DR DALLAWAY remarks, that "the whole plain of Troy, "from the height said to have been the citadel, is of uninterrupted extent." (p. 346.). From the promontory also of *Yeni-cheybr*, or Sigeum, at its lower extremity, the same intelligent traveller looked over the plain, the whole scope of which he commanded. "Its broadest diameter," says he "may be five "or six, and its longest twelve miles to *Atché-keuy*. It is naturally verdant and fertile, and now very generally cultivated, "excepting near the marsh, which occupies a fifth part." (p. 347.). This I take to be the marsh at the mouth of the Simois, of which afterwards.

The

* See their Letters, Appendix, No. V.

The Site of Ancient Troy.

NEAR the eastern extremity of the plain, upon a gentle acclivity, is situated, as has been said, the Turkish village of *Bounar-bashi*. While M. CHEVALIER advanced upwards to this village, by a pleasant and easy ascent, rising gradually from the plain, he passed through a spacious cemetery, where each of the tombs is adorned with a fragment of marble or of granite. Passing the village he continued to ascend for near a mile, till he arrived at the borders of a precipice of great height. (Ch. IV.). Beneath this precipice a torrent, coming down from the mountains above the plain, (but whose bed in the summer is commonly dry), runs in a curve direction toward the north; and, bending its course along the northern side of the plain, flows down through the whole length of it, and discharges itself into the Hellespont, betwixt the modern Turkish fort called *Koumkaleb* on the south, and a sort of haven called *Karanlik-limani* on the north, near Rhœteum. This river is undoubtedly the Simois. And upon the rising ground extending upwards from the village of *Bounar-bashi* to the abrupt precipice encompassed by rocks above and the river below, on every side, except that which opens upon the village, and where the Scæan Gate may be supposed to have been, M. CHEVALIER concludes, that the ancient city of Troy was placed. From the summit of this high ground, where he supposes the citadel to have been, and which the Turks now call *Ballidabi*, *mountain of boney*, he had a view, as has been said, of the whole extent of the plain. This being an airy situation, justifies, in his opinion, HOMER's epithet of *ἠνεμόεσσα*, so often applied to Troy. (Ch. XVII.). The precipices which skirt this eminence, and the Simois which runs at the foot of them, render the place impracticable to be assailed from any other quarter than from the side towards the village. (*Ibid.*).

Mr

M. CHEVALIER further remarked, on this high situation, four barrows or *tumuli*, three of which are similar to those on the shore of the Hellespont, (which shall be afterwards mentioned), and the fourth consists of an enormous mass of stones. This he conjectured to be the monument of HECTOR ; and thought it the remains of a demolished structure. (Ch. XVII.).

MR HAWKINS and Dr SIBTHORPE "spent a day in visiting the hill supposed by M. CHEVALIER to have been the site of Troy ; and the springs of water, which he considers as the fountains of the Scamander*." Mr HAWKINS thought, that the place pitched upon for the site of the city has much natural strength to recommend it, particularly the easternmost angle of the hill, which, from its height above the Simois, and its perpendicular form, must have been considered as a very strong natural fastness in those times of warfare, and could have been easily rendered an impregnable citadel ; for it is not large enough for the site of the whole city."—"Some *tumuli*," adds he, "near the spot, are certainly strong indices." Dr SIBTHORPE observed, that "the situation, where the citadel is supposed to have been, is particularly steep and rocky:" and that "it is covered with prickly barnet, and a few thorny shrubs. The almond tree," adds he, "which grows wild, is not without its thorns. It has even more pleasing plants, the yellow jasmine and the wild olive."

MR LISTON took particular notice of a contiguous place, where the stones of what is called the tomb of HECTOR seemed to have been dug ; and he remarked a sort of hollow all around the city, except some part, which is rocky.

DR DALLAWAY, who advanced towards the village from the northern side, thus describes his approach : "As the setting sun was more brilliant than for many days past, the village of

VOL. IV.

f

Bounar-

* See their Letters, Appendix, No. V.

" *Bounar-basbi* opened upon us very pleasantly from the ford of the Simois, which we passed within a furlong of the chiftlik of HADGI MEHMET Agha, the present proprietor of a domain producing near L. 5000 Sterling *per annum*, and including little less space, and the identical ground of the kingdom of old PRIAM *. His house is mean, but many columns were dispersed about it, which had been collected from the sites of adjacent cities. From the village," adds he, " the hill rises rapidly, and soon becomes an insulated mountain. The lofty wall of Troy, and the Scæan Gate, intersected the modern village of *Bounar-basbi*. Ascending the hill, thickly strewn with loose stones for the space of a mile, the first object on the brow is a stony hillock, which CHEVALIER, with no apparent reason, calls the tomb of HECTOR. It has been opened and examined, but we could not learn the result. There are others covered with grafs, appropriated likewise to Trojan heroes." Dr DALLAWAY has given a beautiful design and engraving of the *tumulus* said to be HECTOR's. This learned traveller is of opinion, that " upon the area and the intermediate ground from the village of *Bounar-basbi*, there is undoubtedly space enough for such a city as Troy is described to have been." (p. 345.). And he observes, that " the level falls abruptly on the south, with a precipitate cliff, into a deep ravine, forming a mural rock, now almost covered at its base by the stream and sands of the Simois, for the length of forty or fifty yards, and completing a fortification rendered impregnable by nature;

* M. CHEVALIER had said, (Ch. XVII.) that " near the hill were situate the gardens of PRIAM, where LYCAON, when cutting wood, was surprised by ACHILLES; and on that spot are still situate the gardens of the Agha of Bounar-basbi, who, after *forty* centuries, succeeds to the king of the Trojans, &c. (*Forty*, among the *Errata*, is corrected *thirty*: which Dr DALLAWAY, not observing, has supposed the author guilty of a mistake). Mr LISTON told me that he ate grapes in this very place.

"ture ; and that the face of the ground exhibits nothing worthy
 "of remark ; bushes and huge unhewn stones only being to be
 "seen."

The Sources of the Scamander.

BUT the chief circumstance which ascertains the position of the city is the sources of the Scamander. These M. CHEVALIER was so fortunate as to discover, and describes as still to be seen, a little below the village to the south, and as consisting :
 1. Of a solitary copious spring, rising from the bottom of a basin, bordered with pillars of marble and granite ; of which spring, in the month of September, he felt the water to be tepid ; but was assured that it is much warmer about the middle of winter ; 2dly, Several small springs of cold and limpid water gushing forth from crevices in the rock, at the bottom of the low hills at the head of the plain, and which uniting into one stream, a little below, receive also the first mentioned fountain, and thus form the Scamander*. (Ch. IV. xix.).

"WE slept," says Dr SIBTHORPE, "at *Bounar-bashi*, a little below which rises the Scamander, fed by numerous springs of a pure crystalline water. One of these is said to be warm in winter ; it communicated to us no sensation of heat." This was about the middle of September. Dr DALLAWAY, who was there in November 1795, speaking of the hot spring, expressly says : "It is at least tepid ; and the Agha (in the front of whose house it is to be seen, at a little distance) told us, that, in the winter months, especially during frost, it is hot and smokes."—"HOMER," adds he, "must be allowed the privilege of a hot spring, and a river full to the brink, if they happen once with-

f 2

" in

* Compare Iliad, xxii. 147.

"in the year." (p. 344). M. CHEVALIER found the Turkish women of the village of *Bounar-basbi* washing their garments at the sources of the Scamander, as the wives and daughters of the Trojans were wont to do when they enjoyed the sweets of peace, before the arrival of the Greeks*. I repeat this circumstance, because Mr LISTON assured me that, when he was there, he made the very same remark.

The Course of the Scamander.

M. CHEVALIER examined the two rivers, the Simois and the Scamander, by tracing them upwards; the latter from the place where it now discharges itself into the Archipelago, by a new canal; and the former from its mouth upon the Hellespont, a little to the north of *Koum-kaleb*. The new canal of the Scamander had been first observed by him, on his way from Alexandria Troas, as he came down from *Udjék-Tépé*, or monument of *ÆSYETES*. About a mile to the northward of this monument, as you pass the village of *Erkeffigbi*, and near an elegant Kiosk, or reposing place, constructed by HASSAN, the Turkish Captain Pascha, a considerable stream flowing down upon the south side of the plain, and then bending towards the Simois, takes a sudden direction to the south, being plainly diverted into an artificial canal, which carries it a considerable way, in a sloping course through a valley, and conveys its waters into the *Ægean Sea*. (Ch. III.). This new canal made a strong impression on M. CHEVALIER's mind; and induced him afterwards to search for the ancient bed of this beautiful stream, which he at length found, and traced, as marked on his map. (Ch. IV.). This was a most important discovery; and when, in the investigation,

* See *Iliad*, xxii. 154.

gation, he came again to the stream, where it turns into the new canal, and traced it up to its sources already mentioned, near *Bounar-bashi*, no doubt any longer remained on his mind, that this was the true Scamander, which had formerly united its water with the Simois.

SUCCESSING travellers have, in the most liberal and decided manner, confirmed the genuineness of these investigations, and acceded to M. CHEVALIER's conclusions.

"We saw the place," says Mr HAWKINS, in his first letter to Mr LISTON, "where the course of this river was diverted by "an artificial canal to the Archipelago." And he adds, more explicitly in his second letter: "The most essential point in "substantiating the evidence of CHEVALIER is that of the canal, "made to divert the waters of the Scamander from their original course towards the Simois. This canal we can bear testimony to. The errors of Wood seem to arise from the overlooking this circumstance. As for STRABO, he had never "visited the spot in all probability, and relied on the authority "of DEMETRIUS of Scepsis*." Mr LISTON himself afterwards examined the river with the greatest care, and particularly the new canal, and the old bed. This last he crossed on bridges in different places, and was convinced, that when, occasionally, the stream of the Scamander is more copious, part of it still flows into the Simois by this ancient channel. For he differed in opinion from M. CHEVALIER in the idea, that the Scamander is never subject to any increase or diminution; (Ch. IV. xi.); and saw no reason why it should not occasionally swell in the case of long continued and heavy rains; though by no means to such a degree as the Simois, which is sometimes dried up, and sometimes comes down with the utmost magnitude and impetuosity.

* See Appendix, No. V.

impetuosity*. Moreover, Mr LISTON assured me, that from M. CHEVALIER's description, the Scamander seems to be a more diminutive water than it really is †.

"For several hours," says Dr DALLAWAY, "we traced, with the utmost attention the course of the Scamander from the cold or second source, which is a collection of small springs, through the morafs, where for some miles it is positively hid, till we reached the new canal, and saw plainly the ancient bed. The banks of this river, where exposed, are verdant and beautiful, and watered to the brink. M. CHEVALIER's topography and general idea, after a fair investigation, we acknowledged to be ingenious and plausible." (p. 347.).

In characterising the Scamander, M. CHEVALIER mentions particularly "the transparency of the water, which runs upon a bottom of sand and round pebbles, betwixt two verdant banks."

Dr DALLAWAY says of the two rivers: "Simois has broad sands, with a sudden and rapid current; Scamander is transparent and regularly full, within a narrow channel, and so they continue to be till their junction, before they reach the sea." (p. 348.).

M. CHEVALIER further describes his having passed the Scamander upon an old willow stretched across, near a mill. Mr LISTON also mentioned to me this mill, and his having crossed the current in a similar manner.

(ix. vi. 110) ; nous sommes à l'extrémité d'un bras de l'ancien fleuve. *The*

* If this hypothesis of Mr LISTON be well founded, perhaps it may be inferred that the Scamander remains in the same state in which it was in the days of HOMER, occasionally flowing into the Simois, but commonly, by what is thought a new canal, into the Ægean Sea. And if this is admitted, it may assist Mr HEYNE in obviating a difficulty which occurs to him in his Essay on the Topography of the Iliad. See Appendix, No. III.

† PERHAPS I may be partly to blame for this, by calling it, in the translation, a *rivulet*, (p. 13. 15.), and once a *rill*, (p. 25.). The original is *ruisseau*, which might have been rendered a *stream*.

The Course of the Simois.

FROM *Yeni-çeyr*, which is the Sigeon promontory, and which commands an extensive view of the plain, M. CHEVALIER particularly observed the Simois, which intersects the plain along the north side. "Its waters were then dried up; but the width and irregularity of its channel sufficiently demonstrated the nature of its devastations, and its rapidity." (Ch. III.). The Turks call it *Menderé*. An extensive marsh occupies the ground at the place of its discharge on both sides, and reaches almost to the fortrefs called *Koum-kaleb*. This marsh is taken notice of by STRABO by the name of *Στομαλίμνη*, the *mouib lake*. On his way from this place, M. CHEVALIER passed the Simois near its mouth, and found it to be more than 300 feet broad. In the marsh, on its banks, he observed certain small lakes of fresh and of salt water, and was struck with the prodigious quantity of reeds and tamarisks he met with, as he proceeded along the coast. (Ch. IV.). He travelled onwards for half an hour, and saw a large barrow, the monument of AJAX, which he examined, as we shall by and by mention. Having then proceeded as far as *It-Guelmes* or *Erin-keu*, he returned, and resolved to ascend towards the source of the Simois; and had not proceeded far, when he was so fortunate as to discover, to the right, the bed of a smaller river, at that time dry, and covered with plants and turf. This proved, on a nearer investigation, to be the old bed of the Scamander. If Mr WOOD had adverted to this, instead of still searching higher up for the confluence of the two rivers, he probably would have given a more rational account than he has done of the present state of the scene of the Iliad.

AFTERWARDS, when M. CHEVALIER had examined the Scamander, its sources, and the situation of ancient Troy, as already mentioned, he resumed the design of tracing the Simois still higher ;

higher; and went down to its banks, from the village of *Arabler*, about half a mile to the south-east of *Baunar-basbi*. The torrent being then dried up, he resolved to ascend within its channel, scrambling over trunks of trees and rocks borne down by the impetuosity of the current. (Ch. IV.). He walked for five hours between two chains of abrupt rocks, which border the valley, and came into a plain, with a village at its entry, called *Iné* or *Ené*. Here he found that a river discharges itself into the Simois, and that it takes its rise near a village called *Babar-lar*, to which he proceeded in five hours journey to the southward, through a rugged and mountainous country. This stream he found to be the supposed Scamander of Mr Wood. Returning to *Ené* he continued to trace the Simois, now the *Menderé*, up to the high mountain, whence he was assured it issued. This proved to be Mount Cotylus, now called *Cas-dabi*, the mountain of the goose, from which, misled by DEMETRIUS of Scepsis, STRABO makes the Scamander to flow down, confounding it with the Simois. M. CHEVALIER resolved to ascend to the summit of the mountain, which, after being hindered from doing for some days, in consequence of a great fall of rain, he at last effected; of which expedition he gives an interesting description, particularly of the sublime prospects he obtained.

It does not appear that any of the subsequent travellers I have mentioned, went to the source of the Simois, or the summit of Mount Cotylus, as M. CHEVALIER did: but Dr SIBTHORPE remarks, that the situation, where they supposed the citadel of Troy to have been, is particularly steep and rocky, and is girt by the Simois, "which is now," says he, "entirely dry: but perhaps the winter torrents may raise it into a considerable river. Its banks are fringed with plants, agnus castus, and tamarisk *."

DR

* See his Letter, Appendix, No. V.

DR DALLAWAY crossed the Simois three times: 1. On his way from *Udjek-tepé*, or the monument of *ÆSYETES*; and after he had rested during a tempestuous night at the *Cbiftlik*, built by the famous *HASSAN* Pasha, formerly mentioned, on the 5th of November he crossed both the Scamander and the Simois, the latter of which the rains had increased to a considerable river; the bed being from forty to fifty yards wide; though it is frequently almost dry, especially in the midst of summer. This was on his way to the village of *Thimbrek-keuy*, and the temple of *APOLLO* *Thymbræus*; which he passed and descended to the shore, and proceeded as far as Cape *Berbier*; and after exploring the shores of the Hellespont, he returned by sea to *Koum-kaleb*. Here having landed, he again crossed the Simois over a wooden bridge, near its *embouchure*; (p. 338.); and advancing upwards on the northern side of that river, he repassed it within a furlong of the *Cbiftlik* of *HADGI MEHMET* Agha, at *Bounar-bashi*. (p. 343.). In viewing the situation of the citadel, where the Simois runs under the rock, he says, "That the division of the rifted rock "from the groupe of forest mountains, does not exceed 150 "yards, and is scarcely farther asunder at the top, sinking as "perpendicularly as an artificial channel."

The Monument of ÆSYETES.

M. CHEVALIER, as has been said, began his researches in Asia at Cape *Baba*, the ancient promontory of *Lectos*. From thence he proceeded to the ruins of *Alexandria Troas*; his account of which has been minutely confirmed by *DR DALLAWAY*. But though the narrative of both travellers be very agreeable and interesting, we did not before, nor do we now, think it necessary to detail the particulars. On advancing, his notice was particularly attracted by *Udjek-tepé*, a barrow of an extraordi-

nary size, which already has been mentioned *. He had no notion at first that this was the same with the monument of *ÆSYETES*. He contented himself with measuring its dimensions, and enjoying the magnificent prospect from the top of it. Its height he found to be not less than 100 feet, and its outline to be 400 paces. He remarked it to be of a conic shape, and quite regular. After his third journey to the Troad, he had no hesitation in concluding it to be the monument of *ÆSYETES*. (Ch. III. XII.).

DR DALLAWAY says, that "the tomb of *ÆSYETES*, according to POCOCKE, or, as it is now called, from the adjacent village, "*Udjek-Tepee*, is a barrow of extraordinary height and smooth surface, and was the situation from whence *POLITES*, the son of "*PRIAM*, reconnoitred the Grecian camp, and the opposite island "of Tenedos, with its harbour and promontory †."

Five other Tumuli.

AFTER M. CHEVALIER had examined the new canal of the Scamander, he proceeded, from the place of its discharge into the *Ægean Sea*, along the coast, towards the village of *Yeni-cbeyr*, in order to have a nearer view of several high mounds of earth, which had attracted his attention from the top of *Udjek-tepé*, or monument of *ÆSYETES*. The first he arrived at, called *Besbik-tepé*, is not by any means so high as that last mentioned. He next came to that, which, upon the map, he has called *Antilochi tumulus*, not finding any Turkish name for it, and which seemed to be of the same dimension with *Besbik-tepé*. He then proceeded to the village called *Yeni-cbeyr*, still inhabited by Greeks, and situate upon the extremity of the famous Sigean promontory.

* See above. p. 38.

† *Iliad*, II. 792, seq.

promontory, where, just as he was entering the Church, he saw the Sigeian inscription, so well known to the learned; and opposite to it the bas relief of marble, of the finest workmanship, of which Dr CHANDLER has given an exact account; and there is an elegant engraving of it in *Ionian Antiquities*.

DR DALLAWAY, too, saw this bas relief, as well as the Sigeian inscription; which last, he observes, is now placed at the door of a low hut, consecrated as a chapel: and the letters are nearly worn out, the marble having been so long used as a bench to sit on. Mr LISTON told me, that the effacing seems to be promoted by a drop which falls from the eaves of the chapel.

FROM the top of the promontory M. CHEVALIER had another extensive view of the plain of Troy, and saw particularly the mouth of the Simois, as already mentioned; also the Turkish castle of *Koum-kaleb*, mentioned by all the subsequent travellers. At the foot of the promontory he remarked two other *tumuli*, of which the nearest is understood to be the monument of ACHILLES; and the more distant one M. CHEVALIER supposed to be that of PATROCLUS. Others take it for that of PENELEUS; the ashes of PATROCLUS having been deposited in the same monument with those of ACHILLES.

"ADVANCING some furlongs over the promontory," says Dr DALLAWAY, "we saw the barrow (*besfik-tepè*) called the tomb of ANTILOCHUS by STRABO. On the other side of the village, under the brow of the hill, crowned by half a dozen windmills, near the sea, are two smaller *tumuli*, generally supposed to be those, one of which is attributed, by the ancient geographers, to the illustrious friends ACHILLES and PATROCLUS, and the other to PENELEUS the Boeotian." (p. 350.).

AFTER remaining some days near *Koum-kaleb*, M. CHEVALIER passed the Simois; and, travelling for half an hour, came to a fifth *tumulus* of the same kind with the rest, having a large aperture in its side, which he entered. The monument being de-

molished from top to bottom, its whole interior structure was to be discerned. This is supposed to be the monument of AJAX, and is called by the Turks *In-tepé-Gbeuleu*, the monument of the marsh. It is situated at Rhœteum, a promontory or tongue of land advancing into the plain opposite to the Sigean promontory. (Ch. IV. XIV.).

DR DALLAWAY, after crossing the Simois the second time, passed over an extensive level of ploughed fields, and *Goulusui*, a brook, which empties itself into the sea near *In-tepè*, or the tomb of AJAX Telamonius. "This *tumulus*," says he, "is now irregularly shaped. Near the top is a small arched way almost choked up with earth, which was the entrance into the vault, and over it a broken wall, where was once a small sepulchral fane called *Aiantéum*." He thinks the whole to be of a much more modern date than the death of AJAX.

DR SIBTHORPE, in his letter to Mr LISTON, writes thus: "I write to your Excellency in haste, our vessel tossing about opposite the tomb of AJAX, where it has been just drove by a hard gale of wind *."

* THESE monuments, with the others formerly mentioned upon the hill of Troy, appear to have made a strong impression on M. CHEVALIER's mind; and many of the Members of this Society will recollect, that, in conversation, he used to lay great stress on them. They are objects very conspicuous and striking to those who sail along the coast, near the entrance to the Hellespont, as Mr LISTON particularly informed me. They seem to have made a strong impression likewise on Dr DALLAWAY, who, on viewing them from *Halileli*, near the village of *Thimbrek-keuy*, (p. 340.), remarks, that the succession of the five *tumuli*, under the distant horizon, tend more than any other proof to ascertain the Trojan war. He says afterwards, (p. 349.): "Of all the proofs advanced by M. CHEVALIER, the *tumuli*, so connected
" with

* See Appendix, No. V.

“ with the Sigean and Rhœtean promontories, and the outposts
 “ of the Grecian camp, are the most satisfactory. The site is
 “ likewise confirmed by four others, which, to whatever heroes
 “ they may be conjecturally attributed, with no additional
 “ weight to the argument, give a certain degree of internal evi-
 “ dence, and ascertain the scene of great military transactions,
 “ or vicinity to a large city.”

The Valley of Thymbra.

ON quitting the monument of AJAX at the Rhœtean promontory, and after taking a view of a small adjacent harbour called *Karanlik-limani*, the shut haven, M. CHEVALIER continued his journey to the village of *It-Guelmes* or *Erin-keuy*. It appeared to be of no consequence to the end in view to proceed in that direction any farther, and he returned, in order to trace the circumference of the great plain. On his way back, he soon descended into a delightful valley, called *Thimbrek-deré*, the valley of *Thimbrek*, or *Thymbra*. On beginning to ascend towards the source of a rivulet, which runs through it, he was stopped on its left bank, opposite to the village of *Hahileli*, by a heap of ruins, among which were some bas reliefs, columns, capitals, entablatures, and inscriptions. He took them for the ruins of the temple of APOLLO Thymbræus, and copied some of the inscriptions, which are now published in the third volume of our Transactions.

Mr LISTON saw these ruins, and told me that they are very considerable; some fragments of marble ones still remaining. Every year the inhabitants carry pieces of these to place over the dead in the adjoining cemetery, near the ruins of an old mosque; so that soon nothing will remain but the large pieces. M. CHEVALIER, in his map, has, in Mr LISTON's opinion, placed

ced them too far up. They are at least half a mile from the village of *Halileli*, on the opposite side of the rivulet. Dr DALLAWAY has given an elegant engraving of them, and says, that he "passed the village of *Tbimbrek-keuy*, and a dilapidated mosque, "with a cemetery full of parts of fluted columns and cornices, "set up as memorials, the probable site of the temple and city "sacred to APOLLO Thymbraeus." (p. 331.).

The Promontories.

M. CHEVALIER agrees with all preceding travellers, in holding the promontory of Sigeum to be at the modern village of *Yeni-cheyr*. That of Rhœteum he has no doubt in fixing at *In-tepè-Gbeuleu*, near the harbour called *Karanlik-limani*, where the barrow, supposed to be the monument of AJAX, is still to be seen. He concludes, with the greatest reason, that M. d'ANVILLE and Mr WOOD are mistaken in placing the Rhœtean promontory at Cape *Berbier*, which, according to the latter, lies about 12 miles from the Cape of *Yeni-cheyr* or Sigean promontory. (Ch. XIII.). He was at the pains to measure the distance betwixt what he thinks the two promontories, and found it to be 3000 fathoms, which agrees with PLINY's account, who says it is 30 stadia. M. CHEVALIER thinks STRABO mistaken when he reckons it at 60 stadia.

Dr DALLAWAY observes, that "the entrance into the great "plain is formed by the Sigean promontory, and that called "Rhœteum, about four English miles asunder, through which "the two rivers Simois and Scamander at length took an united "course. Between these promontories the Grecian fleet was "drawn up on dry ground, and probably remained so during "the whole war." (p. 336, note.). "WOOD," adds he, "mistakes Cape *Berbier* for the Rhœtean promontory, which
"STRABO

"STRABO makes to be 60 stadia, SOLINUS, 26, and PLINY, 30, from the Sigeum; the latter is the true distance. (p. 337. note.).
 "The city of Sigeum covered the shore between the *tumulus* and
 "a bay, in which I anchored for a week, (Nov. 1795), and re-
 "surveyed the whole with attention."

Some Mistakes admitted, and corrected.

AFTER what has been stated, and thus confirmed by such respectable authorities as have been adduced, no reasonable person can now doubt that M. CHEVALIER has given a true and distinct account of the present state of the Troad. But as he has had occasion to offer various hypotheses, and to make various observations and inferences, during the course of his Essay, it is not to be wondered at that a few mistakes should have been committed, and some unnecessary animadversions introduced. The author was himself sensible of this, as appears from the late letters I received from him *. In the notes, too, which accompany the English version, I now perceive there are some errors, which I wish to take the first opportunity of correcting.

The Map.

M. CHEVALIER, upon information being communicated to him that Mr LISTON, as well as Mr HAWKINS *, had found some inaccuracies in his map, answered as follows: "There is
 "nothing I desire so much as to have any mistakes, that have
 "been committed in my map, rectified; and I most cordially
 "give my aid to every improvement of which that performance
 "is.

* See his first Letter, Appendix, No. VI.

“is susceptible. But I will venture to assure you before hand,
 “that the alterations which may be made will not extend to the
 “monuments essential to the understanding of the Iliad; such
 “as the site of ancient Troy, the sources of the Scamander,
 “the tombs of the warriors, the promontories, &c. All these
 “points are fixed relatively to one another, with a degree of
 “precision sufficient to prevent any change that may be made
 “upon them from materially affecting my work. As to modern
 “monuments, such as Alexandria Troas, &c. I own that I
 “did not think it necessary to pay such a scrupulous attention
 “to them. The line of the coast was done with the greatest
 “exactness, as well as the mouth of the Hellespont and the
 “island of Tenedos; and therefore I suspect that upon this the
 “new map will make no alteration*.”

DR DALLAWAY observes, that M. CHEVALIER has described the artificial canal in his map of the Troad as having much too straight a direction. It is conducted round the hill upon which the *Chiftlik* of HASSAN Pasha is built. (p. 347.).

The Monument of ILUS.

ABOUT an hundred paces up the Simois, from the place where it is joined by the old bed of the Scamander, and near the place where the city called *New Ilium* is supposed to have been situated, M. CHEVALIER had observed the ruins of a bridge, which had been built of hewn stone, and of exquisite workmanship. Fronting these remains, on the right of the river, he saw a sort of rising ground, which he took to be a demolished barrow. This he afterwards fancied to be the monument of ILUS, and probably the same with HOMER's *Ἰλίου πύργος*. In these conjectures,

* See Appendix, No. VI.

jectures; however, he was, after a conversation with Professor HEYNE, convinced he was mistaken; and readily admitted, that his whole XVIth chapter, which is upon this subject, is good for nothing*. After that conversation, also, he was disposed to think that this barrow might probably be that mentioned by HOMER, (*Iliad*, VII. 337.), which was to be destined as a common one for the warriors who had fallen in battle; *ἀνδρῶν ἐν κοινῷ*.

Situation of the Grecian Camp.

CHAPTER XIII, where the author treats of the situation of the Grecian camp, now appears to me to require much amendment. That the camp was situated somewhere betwixt the Sigeon and Rhœtean promontories is generally agreed; but that it occupied the whole space or line of coast in that interval, as M. CHEVALIER has supposed, cannot be admitted. This would have made it necessary for the camp, which consisted of the tents, with the ships drawn out upon the dry land, as was the ancient custom, to occupy the place on both sides of the mouth of the Simois, which M. CHEVALIER, and the other travellers, as well as STRABO, describe as being an extensive marsh. M. CHEVALIER was evidently aware of this inconvenience; and therefore supposes that the Greeks, in the course of the war, frequently shifted their station; and that, at last, in the tenth year, during the summer season, they encamped, in full force, at the mouth of the Scamander, or Simois, for, at the mouth, they were united.

I REGRET that, in the note, I have endeavoured to support this idea, by supposing, that "the Scamander, even in the summer, VOL. IV. 6 "mer,

* See his Letters, Appendix, No. VI.

"mer, when the Simois was dry, continued to convey its pure
 "and perennial, though less copious, stream through the midst
 "of the camp, in the same channel through which the Simois,
 "after having joined it, discharged its winter torrents." (p. 104).
 Ever since I read Mr HEYNE's Essay, I have given up this hypothesis, and willingly accede to his idea, which supposes, that the camp only stretched on both sides *towards* the promontories Rhœteum and Sigeum; and that on the north-east it extended no farther than the Simois*. In this way the whole is rendered clear, and free from every objection. This, however, makes nothing against M. CHEVALIER, but that he was not so fortunate in his hypothesis as Mr HEYNE, on this occasion, which I am sure he himself would have been the first to admit.

MR HEYNE's notion of the situation of the camp is confirmed by Dr DALLAWAY; and the more strongly, as the latter does not appear to have seen the former's Essay on the Topography of the Iliad, or to have known any thing of the coincidence of Mr HEYNE's opinion with his own. In a very distinct note on this subject, (p. 336.), he observes, that "between these promontories the Grecian fleet was drawn up on dry ground, and probably remained so during the whole war." And he concludes the note thus: "The pursuit of the Trojans by ACHILLES, fixes the situation of the Grecian camp between the confluence of the rivers and Sigeum, for they retreated over the Scamander to gain Troy, and he kills many of them in the river."

Of some other Mistakes, and erroneous Criticisms.

THE author, in speaking of the two *tumuli* near the Sigean promontory, (Ch. IV. XXI.), says, that "he was informed by a Greek inhabitant of the place, that the name given to the
 "more

* See Appendix, No. III.

"more considerable of the two was *Dios-tapé*, which he interprets *the divine Tomb*." Mr LISTON observed, that the inhabitants spoke of both monuments by the appellation of *di theo tepé*, which, in their language, has no other meaning than *the two tombs*. He therefore concluded, that M. CHEVALIER had been deceived by the similitude of the sound. This is also noted in Dr DALEWAY's book, with an assertion, (but not of Dr DALLAWAY himself), that the mistake proceeded from M. CHEVALIER's ignorance of modern Greek; which I have the greatest reason to believe to be without foundation.

In examining carefully the surface of the rock of *Balli-dabi*, M. CHEVALIER thought he "distinguished foundations of ancient buildings, the masonry of which had assumed the consistency of the rock itself." Mr LISTON, on a narrow inspection, was convinced that nothing could be discerned but the real substance of the rock, which is indeed rough, of a chalky appearance, and, at first sight, seems as if there was mortar adhering to it. He brought away a fragment of it, which I have here in my custody; and the gentlemen present may judge.

It seems surprising that there should be a total disappearance of every ruin or vestige of a building, to mark the site of so famous a city. STRABO, however, gives a good reason for this, as follows: 'Οπε γὰρ ἐκπεπορημένοι τῶν κύκλῳ πόλεων, οὐ τελέως δὲ κατεσπασμένοι, ταύτης δ' ἐκ βάδρων ἀνατετραμμένης, αἱ λίθοι πάντες εἰς τὴν ἐκείνων ἀνάληψιν μετενεχθῆσαν. Αρχαϊάνακτα γοῦν φασὶ τὸν Μιτυληναῖον ἐκ τῶν ἐκείθεν λίθων τὸ Σίγειον ἐκτεχεῖσαι. (L. XIII. p. 895). For when all the cities around were laid waste, but not entirely demolished; and while this one was totally overturned, all the stones were carried off from it to rebuild those others. Accordingly, they say, that ARCHÆANAX of Mitylené with the stones taken from thence fortified Sigeum. Dr DALLAWAY, speaking of the city of Ilium, once situated near the junction of the Scamander and Simois, and which owed its origin to ALEXANDER and LYSIMACHUS, says,

(p. 338.), "It excites no wonder, that, after so long possession of it by the Turks, not a stone should remain; yet some contend against the existence of Troy, because no vestiges were discoverable when ALEXANDER founded the second city, whilst they admit the latter fact equally unauthorised by present appearances*."

IN a passage quoted from HERODOTUS, in which an account is given of the march of XERXES's army from Sardes to Abydos, the expression—*τὴν Ἰδην δὲ λαβὼν ἐς ἀριστερὴν χεῖρα*, is translated *advancing towards the left branch of Mount Ida*, different from the common way of rendering it, *having Ida on the left*. As this interpretation is disapproved of both by Mr HEYNE and Mr BRYANT, I have no inclination to dispute the point with such learned antagonists, provided they can make it appear, that XERXES could and did proceed, with Ida on his left. "Ida," says Mr HEYNE, "has many branches and ridges. The army may have gone round one of these outskirts of the mountain approaching towards the sea, in such a manner as to leave it on the left †."

FROM M. CHEVALIER's letters, it appears that he was sensible that he had at times introduced unnecessary or inaccurate reflections; of which kind are those in Chap. VI. respecting travellers

* SEE, in Mr WAKEFIELD's letter to Mr BRYANT, (p. 11, 12.), a remarkable fact respecting the total disappearance of *Flaxford Church*, about five miles from Nottingham.

† I OBSERVE, too, that this notion is supported in a paper in the sixth volume of *Commentt. Soc. Reg. Scient. Gotting.* Ann. 1783, 1784; entitled, *HERODOTI ac THUCYDIDIS Thracia*, JOS. CHRISTOPH. GATTERER: with a map, where XERXES's march is traced accordingly. Mr BRYANT enters into a long discussion upon the subject, through which I have no inclination to follow him now, nor shall I afterwards, I suppose, when I come to take more particular notice of his *Observations*; but will freely confess myself responsible for the whole blame of this mistake, having suggested the culpable interpretation to M. CHEVALIER, on my first reading his paper; and I am anxious that he should here be censured only for paying so much deference to my judgment as to introduce an equivalent expression into the French original.

travellers of high distinction, and the priests in the early ages of Christianity: both of which he desires may be struck out in a new edition. The former, I observe, has already been omitted in the German translation; and the latter, which begins thus: "But why did not the priests of the lower empire demolish those monuments?"—has given great offence to, and has been censured and reprobated with uncommon asperity by, Mr BRYANT, in his *Observations*. (p. 42. 43.).

Of the Notice that has been taken of STRABO.

IN giving a description of the Troad, it was necessary to advert particularly to what a geographer so respectable as STRABO has said upon that subject. This M. CHEVALIER has done in his VIIth and VIIIth chapters. STRABO derived the greatest part of his information, relating to the Troad, from DEMETRIUS of Scepsis, who, though he had his residence in those parts, was evidently deceived respecting the true source of the Scamander, and has led STRABO into the same error. They suppose that this river takes its rise in Mount Corylus, far beyond the place where ancient Troy was situated. M. CHEVALIER has shewn this to be a gross mistake; and it is evident that it was likewise the chief cause of Mr WOOD's errors. STRABO saw and frankly admitted the difficulty of reconciling this with HOMER's account in the XXIIId book of the Iliad, where the two sources are explicitly mentioned, the one a hot and the other a cold spring, and both as being in the vicinity of the Scæan Gate; but STRABO has not been successful in his attempt to obviate this difficulty*.

M.

* MR HEYNE, in a note on the German version, (p. 85.), as well as in the preface to the same work, (See App. No. I.), thinks it evident that DEMETRIUS set out on a wrong hypothesis, in consequence of misunderstanding a passage of the Iliad, (XII. 19.). This passage I had quoted and explained in a note. (p. 59. of the English Translation.).

M. CHEVALIER being clearly convinced of this error of DEMETRIUS and STRABO, and struck with the confusion to which it has given rise, has perhaps shewn too great a degree of suspicion of the latter, in respect to some other passages of his account of the Troad; and may have censured him somewhat too keenly. Wherever this seems to be the case, Mr HEYNE, in his notes on the German version, has taken the part of the ancient geographer, to whom scholars have been so long accustomed to look up with the greatest respect: and if I were to publish a second edition of the English, I should certainly, in consequence of *carte blanche* given by the author*, avail myself of Mr HEYNE's assistance to obviate, as far as possible, every objection made to STRABO, except upon the great and fundamental error respecting the source of the Scamander. For this I take to be altogether untenable. "In general," says Mr HEYNE, in one of his notes, "nothing can be objected against STRABO, but in the single case where he has allowed himself to be seduced by DEMETRIUS, and changed the sources of the Simois and the Scamander." M. CHEVALIER perhaps should have been satisfied with gaining this point.

BUT though it should appear, that the author or his editor had, in one or two instances, misconceived or misinterpreted STRABO, where the text is acknowledged to be obscure, not yet having been properly elucidated by any able editor or commentator, this surely would furnish no argument for setting aside M. CHEVALIER's account of the Troad, founded on the author's actual observation, supported by so many subsequent respectable travellers. In the VIIIth chapter he has, with due respect, taken occasion to quote and comment upon some passages of STRABO; from which it is clear, that the plain of Troy has not changed its appearance since the days of that learned writer.

* See his Letters, Appendix, No. VI.

The opening of ACHILLES's Monument.

THE XXIst chapter contains a number of pleasing remarks on the subject of the *tumuli* to be seen on the shores of the Hellespont; and any person of sensibility must, on the perusal, feel his mind affected with a soothing, though solemn, sensation; and be ready to confess, that M. CHEVALIER has there expressed himself in a most elegant and interesting manner. Inaccuracies, however, and redundancies, may now and then be perceived, some of which were pointed out to me by Mr LISTON, and they ought to be corrected in a new edition.

IT appears, in particular, that M. CHEVALIER had not received very accurate information respecting what was found in the tomb of ACHILLES, in consequence of the operation of digging into it, which had been performed after his departure from Constantinople, by the direction of Count DE CHOISEUL GOUFFIER, the French Ambassador. He had been told, that towards the centre of the pile were found "two large stones leaning at an angle the one against the other, and forming a sort of tent, under which was discovered a small statue of MINERVA, seated in a chariot with four horses; and an urn of metal filled with ashes, charcoal, and human bones; which urn was encircled in sculpture, with a vine branch, from which were suspended bunches of grapes done with exquisite art."

THERE does not appear to have been any foundation for the figure of a chariot. There were however some curious reliques found there. Mr LISTON saw at Constantinople the very person who had been employed to conduct the operation of digging; and who had retained some of the fragments in his own custody, which he offered to dispose of. It appears from a letter, published in a note by Dr DALLAWAY, and giving a very particular account of this affair, that this person was the Signior

SOLOMON

SOLOMON GHORMEZANO, son of the late French Consul. After immense labour, he at last discovered the place where the reliques were deposited. When collected, they filled a large chest. He delivered them to his employer M. CHOISEUL, who repaid his trouble with thanks only: but he reserved several specimens, which he afterwards shewed and explained, when the Count was no longer formidable. Of these a list is given in the letter; such as, pieces of burnt bones; pieces of a metal vase; charcoal of vine branches; a piece of mortar and stone; a piece of metal of a triangular shape; pieces of very fine pottery, well painted with wreaths of flowers of a dark olive colour, &c. An account is then given of the strata of earth dug through. Dr DALLAWAY, in the text, says, that "extreme age, and the pressure of the ground, had crumbled into atoms of rust all the metallic substances. The *urn* or *vase*, M. FAUVAL, an ingenious artist, now residing at Athens, received from M. CHOISEUL in its decayed form, and made a model from it, which has been exhibited to several connoisseurs, as much to their surprise as satisfaction." Dr DALLAWAY adds: "And the *goddess, with her chariot and four horses*, seems to prove that the Troad continues to be the land of invention." Yet it is very remarkable that Mr HAWKINS, who saw M. FAUVAL at Athens, expressly says, that this last mentioned gentleman denied the existence of an urn, but spoke of a small bronze image of MINERVA, of which he shewed them a cast. "At Athens," says Mr HAWKINS in his second letter to Mr LISTON, "we fell in with M. FAUVAL, a very ingenious artist, long in the service of M. DE CHOISEUL, who assured us, that M. CHEVALIER's account of the goblet, discovered in the tomb of ACHILLES, is perfectly fabulous. It originated, it seems, from the fragment of a small bronze figure, which, when he had cleaned, and put together, proved to be a very curious image of MINERVA. He shewed us a cast which he had made of it in
"plaster,

"plaster of Paris*." According to M. CHEVALIER, then, there were both an urn and a figure of MINERVA; according to Dr DALLAWAY an urn, but no figure or statue; and according to Mr HAWKINS a small statue, but no goblet or urn. It should seem, therefore, that this affair still stands in need of further elucidation †.

BUT whatever may be thought of these barrows; "supposing," says Mr HEYNE, "that M. CHEVALIER was mistaken, and that the eminences were not at all tombs, the main point remains what it was. The sources of the Scamander are near *Beunar-basbi*, and in that neighbourhood is the site of Troy ‡."

Of the Objections made by Mr BRYANT.

MR BRYANT, whose name has been long so well known in the learned world, has, in the warfare he has thought fit to wage with M. CHEVALIER, been, no doubt, pretty successful in several assaults, where the latter has laid himself somewhat open; (as we have admitted to be sometimes the case); but he has totally failed in obtaining any thing like a decisive victory.

THIS learned gentleman having, thirty years ago, embraced an opinion, not a new one indeed, but, I believe, almost generally esteemed very extravagant and paradoxical, that no Trojan war, such as forms the foundation of the poems of HOMER, was

VOL. IV.

ever

* Appendix, No. V.

† IN the above-mentioned letter, quoted by Dr DALLAWAY, an instance of a very strange pitch of arrogance is recorded. It is there said, that "when the barrows were closed up, Count CHOISEUL caused a sheet of lead to be placed on the bottom, inscribed, *Ouvrage fait par le Comte DE CHOISEUL GOUFFIER, l'an 1787.*"

‡ CONCLUSION of his preface to the German version. See Appendix, No. I.

ever carried on*, and that even no such city as Troy ever existed, had employed himself occasionally, during that long period, in an attempt to establish the truth of this odd opinion. The subject had grown a favourite one; and the author seemed to himself to be upon the point of achieving his great undertaking; when M. CHEVALIER's performance appeared. This obliged him to stop short for a little, and to pause. He took his resolution. Encouraged, by observing some slips committed by an author, as yet raw in the art of systematizing, it seemed more eligible to him to endeavour to reduce the obstructing fabric to a heap of ruins, than to demolish and suppress his own occasional labour of thirty years. The avowed object, then, of Mr BRYANT's pamphlet, is to set aside M. CHEVALIER's *Description*, as unsound and fanciful. I once indeed heard, that, after the *Observations* had come out, the author met with some travellers, who assured him, that M. CHEVALIER's account of the present state of the Troad was a fair and true one; in consequence of which, it was reported, that he had renounced his heretical opinion upon the subject, and was to suppress his *Dissertation*. This I was very glad to hear, as I thought the so doing would have redounded very much to Mr BRYANT's honour. But I was soon convinced that this information was premature, by my receiving a printed copy of the *Dissertation*, in a present, from the learned author himself; in the perusal of which, one, every now and then, regrets (at least this was the case with me) that Mr BRYANT had ever undertaken such a toilsome investigation, employed so much learning, and wasted so much ingenuity, which the appearance of M. CHEVALIER's work, thirty years sooner, might have prevented; and perhaps might have engaged those very talents to assist in supporting and illuminating a system, which

* SEE Mr MACLAURIN's *Dissertation*, to prove that Troy was not taken by the Greeks. Vol. I. p. 43, &c. Lit. Cl. of Transactions of this Society.

which they have now been employed to puzzle, perplex, and obscure. After all, if the learned veteran had seen Mr HEYNE'S *Essay on the Topography of the Iliad**, and Dr DALLAWAY'S late publication, in both of which M. CHEVALIER is so ably supported, I imagine he would have been deterred from publishing his grand sceptical work, notwithstanding the great labour it had cost him.

MR BRYANT, in the introduction to his *Observations*, charges the author and his editor with indulging in severe critical censure against Dr POCOCKE, Mr WOOD, Dr CHANDLER, and STRABO. But I can't help thinking that the accusation is too strongly stated. I hope it was not with an intention to create an early prejudice in the mind of the reader against the persons animadverted upon, and in favour of what was to follow.

WITH respect to the first of the above-mentioned authors, M. CHEVALIER had said, that "his account of Troas, though full of errors, and in every respect obscure, yet proved to him a very useful guide in his researches." (Ch. VI.). He, no doubt, found considerable obscurity, and a number of errors, in Dr POCOCKE'S account; and where was the harm in saying so? But Mr BRYANT, in his complaint that Dr POCOCKE has been unjustly accused, does not subjoin the qualifying clause of the sentence, viz. that "notwithstanding these defects, the work proved a very useful guide;" but he reserves this latter part of the expression, till he find an opportunity of introducing it with more effect, and more fitly for his own purpose afterwards. I am not sure if this way of dismembering expressions, and exposing them in disjointed morsels, should be considered as a very fair mode of attack. If M. CHEVALIER was convinced that Dr POCOCKE was misled by STRABO, and regrets that he did not rather "trust to his own observation, which probably would

have

* See Appendix, No. III.

" have brought him to agree with HOMER," I cannot perceive any very severe censure in this : On the contrary, M. CHEVALIER finds out, and adds a very good excuse for Pococke, which is, that he could not, at that time, have the assistance of a geometrical apparatus in his observations, as it was then hazardous to produce any such to the view of the Turks. On other occasions, M. CHEVALIER pays compliments to Dr Pococke, calling him, in one place, " that excellent traveller," inasmuch, that he appeared to me to have even over-rated his merit. In a note, therefore, (p. 100.), I have ventured to say as much, in as far as related to the art of composition. For, on reading Pococke's travels, I certainly thought him very deficient in point of arrangement, and very confused in the communication of his ideas. This, however, was expressed with all due deference to his veracity, which I believed to be quite unimpeachable. But, if it will give any satisfaction to Mr BRYANT, I am ready to admit, that I may have been mistaken in thinking Dr Pococke a confused and inelegant writer. And yet the late Mr GIBBON, whose acuteness nobody will deny, when he pays a compliment to Dr Pococke's plan of the seven hills of Constantinople, adds, " that this traveller is seldom so " satisfactory."

• As to the manner in which Mr Wood is treated, it will no doubt seem very disrespectful in the eyes of those who are disposed to believe in his doctrine concerning the source of the Scamander; but to M. CHEVALIER this appeared so palpably untenable and absurd, and he was so conscious of his victory, that he has, no doubt, pursued his triumph with a great deal of vivacity and pleasantry. Where Mr Wood appeared to have merit, it has been allowed him; but because he viewed the Troad erroneously, Mr BRYANT thinks it inconsistent to admit that his description of the coast is exact; and smartly says, (with what

what reason I leave others to judge), "a man so erroneous, and so exact, was never before seen."

DR CHANDLER, in one passage, is blamed for giving his readers too much credit; but a good reason for this is assigned in the note. In another place, he is noted as having once inadvertently spoken of the rivers, repugnantly to his own right notion of them. I have not had time to examine what foundation M. CHEVALIER had for this remark. Perhaps it might as well have been spared. I find it is omitted in the German edition: very probably at the author's own desire. Of DR CHANDLER, M. CHEVALIER speaks elsewhere with the greatest deference and respect; and I question, if DR CHANDLER will thank MR BRYANT for coming forward as his champion, where he had not himself observed any antagonist on the field.

It is surprising that MR BRYANT, in his zeal for the reputation of STRABO, did not perceive that he himself is as guilty of rejecting the testimony of that admired geographer as M. CHEVALIER, when it happens to disagree with his own ideas. An instance of which we find in his *Dissertation*. (p. 44). "Of Troy," says he, "there is no sign: no remainder: nor was there ever any upon record."—"STRABO endeavours to give a reason for this: but I believe that it will not be deemed satisfactory." And so he produces the passage which we had occasion to quote above. (p. 59.).

MR BRYANT employs the first three pages immediately succeeding his introduction, in endeavouring to prove that the city of Troy, as described by HOMER, must have been much nearer the sea than the situation assigned to it by M. CHEVALIER, which is asserted to be contrary to the very evidence of the poet himself.

I AM glad I have it in my power to give a very short, and, I think, a very satisfactory answer to this objection; and I feel the more so, because MR BRYANT's arguments have, in this particular,

ticular, brought over to his side a very learned and intelligent Reviewer in the *British Critic*, (May and June 1797); infomuch that, after combating Mr BRYANT successfully in the other parts of *the Observations*, he at last feels himself under the necessity of seeking for the site of Troy farther down the plain, in which I am sorry I cannot go along with him. The answer alluded to is furnished in a few words by Dr DALLAWAY; and coming from one who has been upon the ground, must have more weight than any thing which could be said on the subject by a person who has not had that advantage. "The distance from the Grecian camp to the site of Troy," says this accurate observer, "has supplied those who contend against its existence with many plausible objections. It is, however, certain, that the present village of *Koum-kaleb* is situate on a sand-bank more than a mile in extent, which will reduce the distance, supposing it to be an accretion from the Hellespont, to less than eight English miles from *Bounar-basbi*, where the Scæan Gate once stood. The advanced works, both of the Greeks and Trojans, lessened the intermediate space. The distance of the most advanced rank of ships from the sea is not mentioned; perhaps we might not be far from the truth in supposing it half a mile, and a quarter of a mile farther from thence to the sea. Allowing the first circumstance of the accretion at *Koum-kaleb*, and the Grecian camp having been advanced into the plain, the distance of Troy is perfectly reconcileable with every incident mentioned by HOMER. It is likewise evident from the circumstances of the war. Had the city been very near, the first work of the Grecians must have been a strong fortification to prevent sudden attacks; without it, their destruction must be inevitable. Besides, there had not been a theatre large enough for the actions of the war." (p. 336, 337.)

MR BRYANT afterwards, (p. 14.), argues from a passage of HOMER, (*Iliad*, XX. 216.),—ἐπεὶ ἔγω Ἰλίου ἐν πεδίῳ πεπόλιστο,—that Troy must have been situated in the plain, much nearer the ships than M. CHEVALIER imagines. To this Dr DALLAWAY also gives the following satisfactory answer: “The most elevated ground on the edge of a precipice was the Acropolis, otherwise called Pergamus, (*Iliad*, IV. 507. V. 460. and XXIV. 700.). Ilion was lofty enough to be called *windy*, (*passim*), yet it was lower than Pergamus, (XXIV. 700.); so that it is once said to be in the plain, ἐν πεδίῳ, (XX. 216.), as standing at the head of the plain on an easier acclivity, and being lower than the mountains of Ida. It is, notwithstanding, incontrovertible, that Troy stood on the ascent, (VI. 74. XXIV. 390.); and the ἐρεισός, which was without the town, has the same epithet *windy*, (XXII. 145.), from its unsheltered situation. The wall extended only in the front of the plain, the natural fortification of cliffs above the Simois rendering its continuance unnecessary. Mr BRYANT lays much stress on the expression ἐν πεδίῳ, which might have been used comparatively, and in contradiction to higher acclivities, and not positively.” (p. 349.).

WHAT Mr BRYANT says of the distance between the promontories, the situation of the Grecian camp, and of the θρωσμός πεδίου; (p. 4. to p. 13.); also his criticisms relating to STRABO, and upon a passage of HERODOTUS, (p. 15.—28.), do not here require a particular answer or discussion, after the concessions already made, and the amendments which have been proposed. In the case of a new edition of M. CHEVALIER's *Treatise*, it is admitted that several of Mr BRYANT's remarks might furnish assistance in the correction of some errors and inaccuracies, and would merit a tribute of praise to the learned author's acuteness; but they can have no effect in subverting the great and essential articles of M. CHEVALIER's investigations and discoveries.

NOR will I enter any further into what is objected to the account of the Scamander, taken from the diminutive size of the river; enough having been already said upon that subject to convince any unprejudiced person that the stream, which has its sources at *Bounar-bashi*, and which has been explored and described by other respectable travellers, as well as M. CHEVALIER, answers perfectly to all the descriptions and hints to be found in the *Iliad*; allowance being always to be made for the poetic way of representing such things*. Enough too has been already said concerning the tombs.

THE passage in the description, where M. CHEVALIER has exposed himself most to the power of Mr BRYANT, is contained in two paragraphs in the VIth chapter, where CLEMENS Alexandrinus is referred to, and where the priests of the lower empire are mentioned. The observations there made are evidently ill digested, and rashly thrown out. This the author has frankly admitted, by directing them to be totally rejected in the case of his book's being reprinted†. But still this does not in the least affect the material parts of the *Treatise*; and such diminutive or partial victories as this will scarcely entitle Mr BRYANT to the honour of an ovation, far less to the glory of a triumph.

MR BRYANT, I find, willingly allows the author and the editor some praise for exploding the idle notion of HECTOR's flight three times round the city of Troy; and supports them in their endeavour to show the absurdity of such a supposition. At first I was afraid there might be some sort of decoy in this, some contrivance, like that of the wooden horse, for destroying us; especially as this was a quarter (—ἐνθα μάλιστα Ἀμβρατός ἐστὶ πόλις, καὶ ἐπιδρόμοι ἐπλετο τεῖχος—) where I never had felt very bold, having still had my doubts about the poet's acceptance of *περί*. But

* See Mr HEYNE's Preface, Appendix, No. I.

† See Appendix, No. VI.

But I was soon convinced that Mr BRYANT had no treacherous design in making this concession; and the hypothesis having also the strong support of Mr HEYNE *, there is now good reason to be confident that it is well founded.

M. CHEVALIER, in the beginning of his XIIth chapter, had remarked, that Mr BRYANT has endeavoured to prove "that the Greeks were mistaken in supposing those to be the tombs of heroes, which were in reality consecrated mounds." This observation, it seems, was of too general a nature. Mr BRYANT meant what he said to be taken in a limited, not a general, sense; and thinks himself much injured by this misrepresentation. He wishes, therefore, that M. CHEVALIER had passed him by unregarded; and in this wish I heartily concur: for I am sure M. CHEVALIER will sincerely regret that he should have written any thing that could be construed into a design to injure Mr BRYANT's reputation; which I am as much convinced he never intended, as I am conscious that I never meant, by the long unfortunate note subjoined on the subject of barrows, to support him in any such design.

BUT in following Mr BRYANT any further, I am afraid I should trespass on the indulgence of the Society. I did formerly, and do now, entertain a high respect for that gentleman's talents, learning, and character: at the same time, I cannot help lamenting, that he should ever have misemployed those talents, and that learning, in a laborious attempt which can never enlighten the mind with any cheerful rays of conviction; nor ever reach beyond a dreary and disgusting state of obscurity and doubt, tending to blunt or extinguish those pleasing sensations which the poems of HOMER excite in every breast qualified to feel their genuine spirit; and for a diminution of which, the efforts of a frigid and phlegmatic erudition, even if successful in proving them to have been derived entirely from fiction, would scarcely be able to compensate. But that "the war on which

VOL. IV.

k

"HOMER

* See his Note, Appendix, No. II.

"HOMER founded his famous poems was never carried on, and
 "that, if the city called Troy ever existed, it must have been in
 "Egypt, and not in Phrygia ;—nay, that HOMER himself, un-
 "der the name of ULYSSES, was the hero of his own Odyssæy,"
 are paradoxes, I should think, too whimsical, too violent, and too
 repugnant to the best authorities of antiquity, ever to admit of
 any thing like a proof.

ON the other hand, that the scene of the Iliad has derived
 great light from the laudable researches and fortunate disco-
 veries of M. CHEVALIER must be allowed; and therefore he de-
 serves the thanks of every admirer of the works of the great
 poet. This is the decided opinion of many; and particularly
 of one, whom the world allows to be qualified in an eminent
 degree to judge of this subject, the learned and sagacious Pro-
 fessor HEYNE; to whose Essay on the Topography of the Iliad,
 which is annexed in the Appendix*, I beg leave to direct your
 attention.

APPEN-

* No. III.

*APPENDIX, containing Papers and Letters referred
to in the foregoing Detail.*

No. I. (p. 31.).

*From Professor HEYNE's Preface to the German Translation of M.
CHEVALIER's Treatise*.*

TO penetrate, at least with the mind's eye, beyond the narrow circle to which life is bounded, and to study nature on a large scale, is a propensity in the constitution of man. From this principle arises the pleasure which we receive from the description of foreign lands, and in the representation of natural scenes and prospects. In the case of celebrated places, this pleasure is enhanced, when, in countries well known to fame, the remembrance of illustrious actions is before us. The interest rises still higher, if the spot be what is termed classic ground, the mention of which in ancient authors is connected with important events; or where the topography is doubtful, and has become a subject of controversy.

THIS is the case with the Troad. HOMER furnishes us with so much accurate observation, that we are ready to imagine ourselves

k 2

selves

* I AM indebted for the translation of the following Extracts, from the German of Mr HEYNE's Preface and Notes, and of the Essay on the Topography of the Iliad, to a very ingenious young gentleman, now the Reverend ALEXANDER BRUNTON, minister of Bolton in East Lothian; formerly educated at this University, and who resided some time at Berlin, as private secretary to the late JOSEPH EWART, Esq; British minister at that court. My learned friend, Mr JAMES BONAR of the Excise, took the trouble of revising and preparing it for the press. D.

selfs able to make a visible representation of the country. But if we try to complete the picture in all its parts, we shall meet with gaps and with places which do not coincide with the rest of the design. Accurate descriptions of this district have not been obtained.

STRABO is the only author who has furnished us with a minute account of the Troad, composed not from the personal observations of this great geographer, but borrowed from DEMETRIUS of Scepsis. DEMETRIUS seems indeed to have a just title to belief and respect, as he was born in the neighbourhood of the Troad; and had in all probability surveyed it himself. Our good opinion of him is confirmed by the accuracy with which particular places are laid down, and by their coincidence with the descriptions of the ancient poets.

THIS author, however, gives rise to a still greater embarrassment, not so much respecting the situation of Troy, for it is assigned to what, in all probability, is its exact place, as in regard to the river Scamander and its sources, which are thrown far back in the mountainous region behind Troy.

SUCCEEDING travellers have thrown little light on the Troad. WOOD, alone, made it a serious object to explore this classic ground, and to form an accurate idea of it. He was prepared for the investigation by classical erudition. He travelled, he says, with his *Homer* in his hand, but he seems to have had STRABO alone in his eye. Without attending to so many other circumstances, which might have directed his view, the sources of the Scamander were his only point, from which he surveyed every thing else; and as he was mistaken in the situation of these, every thing else must have received from him a false position and appearance*.

To

* AN ingenious criticism on WOOD's *Essay on HOMER*, which appears in the original of this preface, is here omitted, as not immediately connected with the present subject. D.

To the edition in 1775 of WOOD's *Essay on the Original Genius and Writings of HOMER*, was added his *Comparative View of the ancient and present State of the Troad*. Some years afterwards, I read in the Society a paper attempting to explain the military transactions in the Iliad, according to the topography of the country *. Had I kept by HOMER I should have fallen into fewer mistakes: but, unfortunately, from confidence in such a man as WOOD, who had visited the country with his *Homer* in his hand, I took him and his chart of the Troad for my guides, and thus allowed myself to be entangled in such a labyrinth of errors, that I strove in vain to extricate myself.

THE main blunder in WOOD is the alteration of the sources of the Scamander, and the consequent placing of ancient Troy deep in the mountainous region of Ida. Every thing else was now confounded. WOOD did not perceive that DEMETRIUS of Scepsis, whom STRABO follows, builds, in this instance, on a mere hypothesis. DEMETRIUS, I imagine, founded it on an erroneous interpretation of Iliad, XII. 18, &c. †, which he understood geographically, without considering that he had before him a poet, not a geographer. WOOD, indeed, traced the course of a stream, till at last he found another that flowed into it: he then sought the sources of this new stream, and discovered them. Thus far, all is accurately observed, and coincides with DEMETRIUS's assertion. But was this stream of course the Scamander? and was Troy to be immediately transferred to that spot? Had not STRABO preceded him with a multitude of doubts? WOOD helped himself out with changes of nature, which must have taken place here, and have altered of consequence the face of the country. But such changes history knows of only upon the coast, or when occasioned by the overflow of rivers:

* This paper is published in *Commentat. Soc. Reg. Scientiarum Gottingensis*, tom. VI. under the title of *De acie Homerica, et de oppugnatione castrorum a Trojanis facta*.

† See above, p. 61.

rivers: and such HOMER himself describes, *Iliad*, VII. 459, &c. XII. 13—33.

THE transference of Rhœteum to Cape *Berbier* is an error not peculiar to WOOD: but the Grecian camp derives from thence an extent which again does not accord with HOMER's description. The poet is not indeed to be a geographer; but he must not feign any thing which contradicts the first glance at nature, or clashes with the known accounts of the topography of the country. The epic poet must represent nature as certain leading circumstances require. The main circumstance here is the general chart of the face of the country, and an establishment of certain principal spots. As to the rest of the scene, fancy must have full play in suggesting its greatness and extent. The epic poet's chief engine is the marvellous. By an accurate determination of every particular, the illusion would quickly vanish. Much must appear only in great masses. Some things must be and must remain in obscurity, that the fancy of the hearers or readers may have room to work, to form to itself an idea of greatness and power. HOMER therefore does not give an accurate determination of the Grecian camp, or of the field of battle. Here the fancy of the reader has room to operate, as that of the poet himself has been engaged in working up every thing into the great and wonderful. Every thing appears to him many degrees higher than it is in real nature. Must he not raise the reader to the same pitch? "I see gods arising" is the language of the poet; and when he is read as a poet ought to be, it will be the language of the reader also. If we are at any time to figure to ourselves the Scamander as a tremendous torrent, which, as a god, fights with ACHILLES, and threatens to bury him in its waves, HOMER must not inform us how diminutive its real size is. He must leave us, by association with the greatness of the effect, to give it all the bulk our fancy can grasp. He in no place gives the exact dimensions of the town and fortress of Troy. This is quite

quite natural; for such accuracy could in no respect have had an advantageous effect. The combat of ACHILLES and HECTOR is filled with the *wonderful*. The race of both heroes is traced by means of points, which the fancy of the reader may extend as far as it can; the walls, the wild fig tree, the watch-tower, the sources of the Scamander. But it may be premised, that to a person who knew the topography of the country in the days of HOMER, nothing would be represented, which he would have recognised and declared to be false and erroneous, else the effect of the poem would have been lost.

WHEN we speak of the Troad, it may be viewed in various lights. What is the present appearance of that country? What was it formerly, at different times, particularly in the days of HOMER? and how can its present appearance be reconciled with the descriptions of that poet? Or, again; in HOMER there is a certain appearance of the country described. How far does this actually accord with nature? Each of these views and questions it is rather the province of the geographer and historical critic to answer. There is still another view of the subject. As the poet cannot be read with pleasure, without a sensible representation, what is the representation he gives of the face of the country? To what extent does he give it? and how much of this kind of knowledge must accompany or precede the reading of the Iliad?

THE explainer of HOMER is properly bound to discharge only the last task. With this view I had entirely new modelled the above mentioned Memoir, according to HOMER, and had taken no further assistance from STRABO than coincided with and illustrated HOMER's account. So much the more lively was my pleasure, when I perceived, in the paper of M. CHEVALIER, a greater coincidence with my ideas than I had found in WOOD, or in any other work. This induced me to annex to
this

this publication my Memoir in a new dress, in order, at least, to remedy the errors it may have formerly occasioned.

THAT the sources of the Scamander are still found near *Bounar-bashi*;—that of its junction with the Simois the ancient channel still remains, as the stream is now diverted into a canal, which falls into the sea below Sigeum;—that the stream which comes down from the hills is the Simois, and not the Scamander;—and, also, that the other stream, which the former receives, is no Scamander;—that *Bounar-bashi* exhibits the site and vestiges of ancient Troy;—that even the citadel is still distinguished by its abrupt precipice:—all these are leading remarks and observations which we owe to M. CHEVALIER. The coast, the promontories, the tombs, the temple of APOLLO at *Thymbra*, *Callicoloné*, and other places, receive from him all the distinctness that readers of HOMER can wish.

M. CHEVALIER visited the country about the year 1787. He was at that time, attached to the embassy of M. DE CHOISEUL GOUFFIER at Constantinople. The occasion both of his drawing up the paper, of its being read before the Royal Society of Edinburgh, and afterwards published by Mr DALZEL, are detailed in the preface of this last gentleman*.

I HAD the pleasure of M. CHEVALIER's acquaintance during his short residence at Gottingen. The perusal of parts of his travelling journals made me desirous to communicate to my countrymen the whole work. This proposal, however, was attended with several difficulties, particularly, that the paper was the property of the Royal Society of Edinburgh, and that it was assigned to a place in the third Volume of their *Transactions*, which was not to be published for a twelvemonth.

IN the mean time, upon signifying my wishes, I experienced a complaisance and readiness to oblige, which calls for the warmest

* See the Preface to the English Translation.

warmest and most grateful acknowledgment on my part. Not only M. CHEVALIER gave me every assistance, but, on the part of the Royal Society of Edinburgh, I was anticipated with assurances which shew the liberal sentiments of those *Literati*, who are far superior to any little selfish vanity. I had even immediate access to a translation of the Paper before it had appeared in the Society's *Transactions*. A copy of this translation was sent to me before its publication, and the earliest impressions of the maps were communicated to me. If ever the occupations of learned men merited the title of the studies of humanity, it was in the present instance. To the exertions of Professor DALZEL, I am particularly indebted. He preserved, on this occasion, his character, already high in my estimation, by shewing himself in no ways actuated by envy, or by any little jealousy, towards a professor in his own line.

I COMMITTED the German translation to a young promising scholar, Mr CHARLES FREDERIC DORNEDDEN. According to the permission which I received from Edinburgh, and from the author, I have added some remarks, which are chiefly critical, or relate to the interpretation, particularly of STRABO, or refer to a comparison of passages in HOMER. On different points I have received from the author written explanations, and have, by his permission, made some changes and additions. The particular state of literature in Germany would perhaps have required other changes, omissions, and abbreviations; but the work was not my property.

THE author sets out always from tombs, and seems to lay the greatest stress on the observations he has made respecting these. There may have been particular reasons for this. For us they decide little. Supposing that M. CHEVALIER was mistaken, and that the eminences were not at all tombs, the main point remains what it was; the sources of the Scamander are near *Bounar-bashi*; and in that neighbourhood is the site of Troy.

No. II. (p. 73.).

Mr HEYNE's Note, additional to Mr DALZEL's, on ACHILLES's Pursuit of HECTOR. (Iliad, XXII. 165.).

LONG as this note has been *, I find it necessary still to sub-join another. We ought, I think, to take up the subject in this way. Here, as frequently happens in regard to HOMER, two distinct questions occur: 1. How the Ancients understood HOMER? 2. How he *may* and *should* be understood?

UNQUESTIONABLY the ancients often understood their *Ho-*mer furprisingly ill; and in the instance before us it may very well have happened that they mistook his meaning. His commentators have constantly been deficient in point of acquaintance with the topography of the Troad. Seldom was this rugged coast visited by travellers, as no great road either led to or run through it. Over the precipices of Mount Ida it was hardly possible that there should lie any much frequented path. To the present hour this coast continues to be but rarely visited. Those tracts only are known to us through which caravans travel. Even where an accurate acquaintance with the topography of the country might have been most confidently looked for, in STRABO for instance, we find nothing more than an abridgment of the accounts of DEMETRIUS of Scepsis; and that this last mentioned author, in his examination of the ground, carried throughout in his mind a preconceived hypothesis, is evident in what relates to the fountains of the Simois and Scamander. This may perhaps have been the case too, when he asserted

* SEE the English Translation of M. CHEVALIER's Essay, p. 135, &c.; and the German, p. 206, &c. D.

ed, as follows, of the place which he had rightly marked out as the site of ancient Troy, "HECTOR could not possibly have been pursued round about New Ilium, but he might very well have been so round ancient Troy," — *ἡ δὲ παλαιὰ ἔχει περιδρομὴν*. (STRABO, p. 895. A.) In QUINTUS of Smyrna, who, as well as DEMETRIUS, resided just upon the western coast of Asia, we find a similar deficiency in point of local knowledge. No wonder, then, that even he makes HECTOR be dragged around the walls, *ἀμφὶ πόλιν*. (I. III. XIV. 132.)

VIRGIL's imitation of this incident, in the combat between ÆNEAS and TURNUS before Laurentum, (quoted and referred to in the Essay), can prove nothing more than that VIRGIL either adopted in his narrative a different plan from HOMER, or endeavoured to give somewhat more probability to his story; just as in another passage we find him substituting, for the triple chase of the combatants, the more probable incident of dragging the dead body of HECTOR round the city;

Ter circum Iliacos raptaverat HECTORA muros.

He observed, in this, the same rule by which he conducted himself on other occasions, not always to be anxious to tread in the very steps of HOMER, but, where a different delineation should offer more poetical beauties, to carry his imitation at large through the whole circle of poets, epic or dramatic. In this particular, of the dragging of HECTOR's body, he followed some other poet, probably EURIPIDES. (See Excurs. XVIII. ad Æn. I.)

If it is to be maintained, that the passage in HOMER, respecting this pursuit of the combatants, cannot mean that it was actually round about the city, and that such a pursuit could not possibly have taken place, the main proof must be drawn from the topographical situation of the country. Ancient Troy was accessible only on the side next the sea. On the quarter of the

Acropolis,

Acropolis it was surrounded by abrupt precipices, and deep ravines; and at the bottom lay the rocky bed of the Simois, as M. CHEVALIER, an eye witness, assures us. His testimony, by the by, affords a solution why the Greeks, numerous as they were, never completely invested the city, though this would have been a natural and effectual plan of operation. It explains, too, why they did not cut off all approach to the place; for we find fresh supplies and provisions received without interruption from Phrygia; allies and auxiliaries arriving constantly at Troy. On the side next the mountains there must therefore have been a free access to the town. Hence, too, it is no less evident, that HOMER, intimately acquainted as he was with the ground, never could have said what has been ascribed to him, that ACHILLES chased HECTOR thrice round the walls. Still less can this be supposed, when what the poet is thus made to say is palpably absurd in itself, that two combatants should run three times round the walls of a city. For either, if we should reckon the thing possible, our idea of the city must be diminutive and contemptible; or, should we suppose the city to be large, the improbability becomes obvious, and we are struck with the absurdity of the army's standing idle, waiting for the re-appearance of the runners from the opposite side of the walls. Add to this, that such an absurdity is by no means necessarily implied in the words; nor would it at all occur, were the passage read without prejudice, and with proper attention to its meaning. All the combats take place before the Scaan Gate. Thus far had PATROCLUS, the preceding day, driven back the flying Trojans. (XVIII. 453. XVI. 712.). No battle, no transaction, is mentioned, as happening in any other quarter, or on the opposite side of the town. It is on the Scaan Gate that PRIAM and his Trojans stand, to be spectators of the fight. (Iliad, III. 145—154. XXII. 25. 462.). Even during the flight of HECTOR, we do not find PRIAM running from one gate to another, from one
side

side of the walls to the other; he continues standing on the Scæan Gate.—The whole narrative of the transaction in question is as follows:—

HECTOR at first takes his station before the Scæan Gate, waiting on foot the approach of ACHILLES, (XXII. 96.); but as ACHILLES draws near, he is seized with a panic. To escape from him, he takes his flight along the foot of the wall, (τείχος ὑπὸ Τρώων. XXII. 144.), partly with the view of being protected from the walls, partly, perhaps, in order to get away towards the mountains. ACHILLES gets between him and the wall, and drives him to the opposite side against the Grecian army. This track brings HECTOR to the watch-tower, the wild fig-tree, and the sources of the Scamander. Here he finds an opportunity to wheel round, and again approach the walls. ACHILLES, once more, interposes betwixt him and the city, and drives him back towards the sources of the Scamander; and this is repeated four times, (v. 157. 165. 188. 194. Ὀσσαί—). On this spot, at a distance from the walls, near the sources of the Scamander, HECTOR at length makes a stand, and the last combat, with his death, ensues.

WHEN the subject is taken up in this point of view, the word *περὶ*, in the phrases *περὶ πόλιν*, *περὶ ἄστυ*, *περὶ τεῖχος*, can be understood in no other sense, than “*about—before* the city,” without any idea of its meaning “*round about* the city itself.” Even the 165th line, Ὡς τὸ πρὸς Πριάμοιο πόλιν περιδινηθήτην, (or rather *περὶ δινηθήτην*), proceeds expressly upon the notion, that the flight was directed away from the city towards the sources of the Scamander; so that no idea of a *round about* can be admitted. The matter is completely cleared up by verses 194—208. The circle of the flight is there accurately marked out, as extending merely from the walls towards the sources of the Scamander; consequently verses 230, and 251, cannot be understood in any other sense.

As.

AS ACHILLES slew HECTOR before the Scæan Gate, so it was decreed that he himself should one day fall before the same gate, (Iliad, XXII. 359. and 360.), *ἐν Σκαίῃσι πύλῃσι*. This is expressed by QUINTUS, III. 82. *Σκαίῃς ἀμφὶ πύλῃσι*.

AFTER HECTOR is killed, ACHILLES expresses the idea,—worthy of a warrior; but which would have embarrassed the poet in the execution, by giving the Iliad at once an inconvenient termination,—the idea of hazarding immediately, while the panic of the Trojans was fresh, an assault upon the city; v. 381. *Εἰδ' ἄγετ', ἀμφὶ πόλιν σὺν τεύχεσι πειρηθῶμεν*. Here, also, it is not necessary to suppose, that the troops were to advance towards the wall round about on every side. The expression implies only something indeterminate in regard to the place, provided other circumstances do not more accurately mark it out. In QUINTUS, (IV. 86. and 87.), DIOMEDE says,

*Ἀλλ' ἄγε, σὺν τεύχεσι καὶ ἄρμασιν, ἧδ' ἐκ ἵππων
ἵομεν ἀμφὶ πόλιν.*

Let us assault the city itself,—On one side, is understood,—in one place, where an assault is practicable. On the contrary, when ACHILLES drags the body of HECTOR round the tomb of ACHILLES, *Τρὶς δ' ἐγύσας περὶ σῆμα*,—(Iliad, XXIV. 16.), it seems clear, from the nature of the thing, that, in this passage, the expression may signify *round about*.

UPON the whole, one must here call to mind the remark, which I have elsewhere introduced,—What other poets do by art, in throwing into the shade certain parts of their story, that the effect of the whole may be more forcible, HOMER does here, certainly not from theoretical notions, but by the guidance of true feeling, and in the glow of imagination! The poet was now arrived at the great, the decisive moment, when his hero ought to appear with the highest lustre. The combat itself is raised to the marvellous; even deities must take a part in it, and contribute

contribute to the wonders of the scene. So terrible is the look of ACHILLES, that HECTOR, prepared as he was to stand the conflict, loses courage at his approach. The race of the two heroes goes far beyond human force; but how far,—over that the poet throws a veil. Fancy has now room to work, and may represent every thing as far beyond what is common and natural as she will or can. They run three times round at the city,—the space, the distance, may be conceived as great as we choose; but the poet neither does nor ought to determine them. Such determination would fall either into the gigantic or the diminutive. The case is different, when, by means of a comparison, an idea and image can be enlarged or extended. The poet then makes use of what is defined, to render the undefined object more distinct, and to throw light on what is obscure. That however is not the case here.

No. III. (p. 34. 67. 74.).

*ESSAY on the Topography of the Iliad**. By Professor HEYNE of Gottingen, Audic Counsellor to His Britannic Majesty, &c.

FOR nine years had the war between the Greeks and Trojans been carried on. The former now lay encamped in the neighbourhood of Troy, when the quarrel between ACHILLES and AGAMEMNON, occasioned a division in the army.

AGAMEMNON,

*The present Essay follows out the train of ideas, suggested in a Paper read before the Royal Society of Sciences at Gottingen, *De acie Homericâ, et oppugnatione a Trojanis factâ*, in the year 1783, published in the fifth volume of their Transactions. All the disquisitions, there introduced, respecting the origin of military tactics, the manner of drawing up an army, and giving battle, and the art of fortifying and attacking a post, as described in the Iliad, are here omitted; many topics, on the other hand, are now corrected and enlarged. That Essay was my first on the Topography of the Iliad; a subject involved in so much difficulty. I allowed myself

self

AGAMEMNON, to convince ACHILLES that, even without his assistance, victory might be obtained, causes the army to march out of the camp, and advance towards the city. Hitherto the Trojans had kept close within their walls, following the advice of their old men*, who saw plainly, that, if a siege should actually take place, the Greeks could make little impression on the town: for the first rudiments of the arts of attack were then hardly known. Encouraged, however, it should seem, by intelligence of the division in the Grecian army, the Trojans quitted the city, and met the Greeks in the field;—a new gratification to the proud spirit of ACHILLES, that now, for the first time, when it was known he was not with the army, the Trojans should venture out into the plain†.

THE two armies met. Four principal battles are described in the Iliad. The first, (the subject of our present investigation), on the

self then to be misled by respect for POPE and WOOD, so far as to renounce my own ideas, and to mould, according to the representations of these gentlemen, the views I had drawn from HOMER himself. I soon found, however, that I had trusted to bad guides, and at once resolved, laying aside all secondary aids, to attempt, from the descriptions given in the poem itself, a sketch of the Topography of the Iliad, such as HOMER exhibits it. This Essay I now present to the public. I had for a long time thrown it aside, when its coincidence with the information collected by M. CHEVALIER on the subject, induced me to revise it, and now inclines me to submit it, for further investigation, to the friends of the poet. Amendment after this will be an easy task.

* ILIAD, XV. 721, &c. The sage POLYDAMAS, afterwards, likewise, when the design of an attack upon the camp seemed likely to misgive, gave his advice rather to retire again within the city, and take refuge, as formerly, behind the walls. But the rash HECTOR would not consent, (XVIII. 266. &c.). Unquestionably the long siege must have proved extremely harrassing. The provisions, as well as the treasure, of PRIAM were exhausted, as HECTOR himself urges. (Ibid. 288.). H.

† ONCE only HECTOR had ventured beyond the Scaean Gate, as far as the beech tree; but on that occasion he with difficulty escaped from ACHILLES. (II. IX. 332, &c.). H.

the plain between the camp and the city, (Il. IV. 422. VI. 306.);—the second, when the Greeks were driven back to their camp, (Iliad, VIII. 55—213.);—the third, which extends not only to the flight of the Grecians into their camp, but likewise to the storming of the camp itself by the Trojans, who break in and set fire to a ship, till at length they are repulsed, and pursued almost to the city by PATROCLUS. Here PATROCLUS falls; and the Greeks, put to flight, are once more driven back to their camp. (Iliad, XI—XVIII.). In the fourth battle, ACHILLES beats back the Trojans again to the city, and crowns his victory by the fall of HECTOR.

No lively idea can be formed, either of these battles, or of the storming of the camp, without some general conception of the environs of Troy.

FROM Mount Ida, run two hilly ridges from the east down to the sea, where two promontories bound a jutting beach. The promontory on the north is Rhœteum; that on the south Sigeum. Within these two ridges lies a plain, sloping down to the shore, and inclosed within their semicircular compass, (STRABO, XVIII. p. 892. B.). In this plain run two rivers: on the north side the Simois; on the south the Scamander, called also the Xanthus. The latter now discharges itself into the sea to the south, below Sigeum, but formerly, before approaching the shore, it must have united with the Simois, so that both rivers had a common outlet into the sea, above or to the north of Sigeum. This *embouchure* was surrounded with many marshes, and hence was called *Stomalimné*; a name which occurs but once in HOMER, in an interpolated passage. (Iliad, VI. 4.). The exact situation is laid down by STRABO, (XIII. p. 890. A. PLINY, V. 20. 33*.).

VOL. IV.

m

THE

* Of all these places, the charts of POPE and WOOD give very different views; that of M. CHEVALIER, however, accords exactly with what is said by STRABO and PLINY.

THE Grecian fleet was drawn on shore at a place between the two promontories. The distance betwixt the two, according to STRABO, (p. 890. B. 891. A.), was 60 stadia, (about two German or nine English miles), in a direct course by sea. The curvature of the land, however, would increase the distance in keeping along the shore*.

It is generally supposed, that the Grecian camp extended from cape to cape. This notion involves very considerable difficulty. Had it done so, the camp must have reached beyond the Simois, and the marshes on both sides of it; a circumstance by no means probable, particularly as the stream is so apt to overflow; and not the smallest trace occurs in HOMER, either of the river running through the camp, or of the left wing being stationed beyond the river. When HOMER, therefore, says, that the ships occupied the whole shore † between the two promontories, he probably speaks in a poetical style, to convey a magnificent idea; and it is more likely that the camp only stretched on both sides towards the promontories Rhœteum and Sigeum, and that on the north-east it extended to the Simois ‡.

WITHIN this space were the ships of the Greeks hawled up on the land, at a considerable distance from the shore, with their sterns towards the land, and arranged in several rows ||. The

* D'ANVILLE, in his description of the Hellespont, (*Memoires de l'Academie des Inscriptions*, tom. XXIV. p. 329.), allows only half the distance; M. CHEVALIER does the same, (Ch. VIII.), on the authority of the passage in PLINY, (V. 33.), where the distance is reckoned from Æanteum. Still, however, it is a contested point, what part of the coast must properly be regarded as Rhœteum.

† ILIAD, XIV. 35. ————— και πλησαν ἀπ' αὐτῆς
 ἥϊόνος στόμα μακρὸν, ὅσοι συνέργησαν ἄκραι.

He does not expressly name either Sigeum or Rhœteum; on the contrary, he always places the camp on the Hellespont, in the more extensive signification of that term, as meaning the northern part of the Ægean Sea.

‡ See above, p. 57, 58. D.

|| THE ships are therefore said to have stood *πρὸς ἄλλησιν*, (XIV. 35.), parallel and behind one another, like the steps of a ladder. That this is the meaning we learn from HERODOTUS, (VII. 188.).

rows, however, must have been drawn backwards, according to the oblique direction of the whole camp, from the north towards Sigeum. Behind the foremost row of the ships the troops were encamped, so that the ships themselves must have served for a kind of rampart, as is plain from a comparison of different passages*. In the rear of the left wing must have been the marshes called *Stomalimné*. STRABO assigns particular names to several parts of the coast, though he has not put them down in geographical order†. As only one part of the coast bears the name of *Station of the fleet*, it may perhaps be inferred from this, that the Grecian camp occupied only a part of the beach.

THE ships stood in the order in which they had been drawn ashore. The vessels of PROTESILAUS, accordingly, occupied the foremost place; and next to them were the ships of AJAX, the son of TELAMON. (*Iliad*, XIII. 681. XV. 706, &c.). AJAX was stationed towards Rhœteum, consequently on the left wing of the camp; ACHILLES, with his Myrmidons, on the right towards Sigeum‡. In regard to the two extremities there is no doubt; but the arrangement in the intermediate space cannot be so exactly ascertained; unless, perhaps, thus far: Near to AJAX, and farther to the right, lay IDOMENEUS, with the Cretans,

m 2

(*Iliad*,

* *ILIAD*, XV. 653, &c. 408. 426. XIV. 34.

† STRABO, (XIII. 890. A.). "After Rhœteum follows Sigeum, a town in ruins, then the station of the fleet, (το Ναυσταθμὸν), and the harbour of the Greeks, (ἡ Ἀχαιῶν λιμὴν), and the Grecian camp, (το Ἀχαιῶν στρατόπεδον), and *Stomalimné*, and the mouth of the Scamander, (viz. of the Scamander united with the Simois), then the promontory of Sigeum." Compare MELA, I. 19. PLINY, V. 30. 33.

‡ *ILIAD*, XI. ad init. It is true that in XVII. 432. it is said, that the horses of ACHILLES would not return without PATROCLUS to the Hellespont, ἄψ' ἐπὶ ἡμάς ἐπὶ πλοῦν Ἑλλήσποντον. But this whole northern arm of the Ægean Sea, before the entrance of the strait, is more than once called the Hellespont. (*Iliad*, XVIII.

(*Iliad*, X. 112.) ; beside him NESTOR, with his Pylians ; then followed MENESTHEUS, with the Athenians ; next to him was ULYSSES ; near to whom were stationed the Argives, Mycæneans, and Lacedæmonians ; after these came several other corps ; and, lastly, on the right wing were the Myrmidons, with whom, it should seem, the other Thessalian tribes (the troops of PROTESILAUS excepted) were united.

By this arrangement, the following passages appear both to be cleared up themselves, and to throw light on others in their turn. The post of AJAX is all along the most important. Towards this wing the main assault upon the camp takes place. To that side also the battles tend. When NESTOR conducts the wounded MACHAON into his own tent, ACHILLES is at such a distance that he sees only his back, and cannot distinctly recognise his person, (XI. 596. 610. et seq.). PATROCLUS, dispatched by ACHILLES to make inquiry, in returning from NESTOR passes the place where the ships of ULYSSES are lying. (XI. 805.). Just at this spot he finds EURYPYLUS, who was coming back from the engagement at the left wing wounded, and was going, it would appear, to the right wing, where probably his Thessalians were stationed. MACHAON, though a Thessalian, was conducted by NESTOR into *his* tent, probably because he was too much exhausted to be able to reach the right wing. The ships of ULYSSES lay in the centre, so that, from thence, the shout, which called the troops to arms, could be heard on both wings*. To this the form of the camp, which, from its position, extended more in depth than in length, probably contributed. Hard
by

150. XXIV. 346. *Odyss.* XXIV. 82. also *Iliad*, VII. 86. XII. 30. XV. 233. XXIII. 2.). And hence must be derived the explanation of the epithets *πλατὴς* and *στενὴς*, which do not seem well applied to the proper Hellespont ; though, indeed, *broad* and *narrow* are relative terms.

* *ILIAD*, XI. 5. These verses are likewise inserted, though rather awkwardly ; lib. VIII. 222. et seq.

by these ships of ULYSSES, and consequently behind the foremost row, was the place for holding the public assemblies, and for the altars for the sacrifices. (Iliad, XI. 806-7.). One of these, it should seem, was the altar of JUPITER Panomphæus*.

THE order of the ships in the catalogue, (Iliad, II.), appears to have some connection with this arrangement in the camp, so that the Boeotians, and those after them, as far on as the Salaminians, under AJAX, belonged to the left wing. The Argives, and those next in order, as far as the Cretans, Rhodians, and other Islanders, composed the centre. The Thessalians, with the Myrmidons, formed the right wing.

THE succession and order of the troops, when afterwards drawn up in the field of battle, is somewhat different. AGAMEMNON runs through the midst of the battle; and after passing some, who are not named, he comes to IDOMENEUS with the Cretans, to AJAX and the Salaminians, to NESTOR with his Pylians, to the Athenians under MENESTHEUS, to ULYSSES, and lastly to DIOMEDE †.

AGAMEMNON, it appears, went from the left to the right wing. ULYSSES was at such a distance from the spot where the Trojans were pressing on to the assault, that he as yet knew nothing of their approach. (IV. 331.). In the battle itself all order

* ILIAD, VIII. 249. 250. OVID. Met. XI. 197. APOLLO stands on the Trojan shore,

*Dextera Sigæi, Rbatæi læva profundi
Aræ Panomphæo vetus, est sacra Tonanti.*

What notion the editors have had of this passage, it is not easy to divine. At all events, a point must be put after *profundi*, and that line must be understood as a complete sentence.

† ILIAD, IV. 231, &c. The leaders and the corps are by no means all particularised by name. Thus, it appears from lib. XI. 808. II. 736. that the Thessalians, commanded by EURYPYLUS, were there:

der is lost; and the combatants, individuals as well as squadrons, are confusedly mixed with one another. (IV. 457, &c.).

THE ground in this neighbourhood must have experienced alterations by the overflowing of the rivers, as well as by the operation of the Simois at its mouth. HOMER himself intimates this, when he takes notice, that not a trace of the wall of the Grecian camp was remaining. (Iliad, XII. ad init.). HERODOTUS also quotes the shore of Troy as an instance of such changes. (lib. II. 10.). And should we even incline to reject the testimony of STRABO, (lib. XIII. p. 890. A.), the fact may be regarded as certain. Whether the alterations of the ground, however, have been so great as WOOD supposes, is a different question*.

BEFORE the camp, as already mentioned, a plain, gradually rising, stretched towards Troy, diversified, it should seem, with several little eminences†. That the two rivers Simois and Scamander inclosed this plain, and that farther down they united with each other, HOMER expressly testifies‡; but he furnishes us with no further or more accurate information||. The field of battle lies in the neighbourhood of the Scamander§, and is called likewise the Scamandrian Plain¶, though it also receives,

* M. CHEVALIER answers this question.

† OF this kind was one immediately in front of the camp, the *θεωμενός πεδῖος*. (Iliad, X. 160. XI. 56.). It lay just before the place for crossing the Scamander, in going from the camp, on the road towards Troy; for in the last battle the Trojans had taken post *ἐπὶ θεωμενῷ ποταμῷ*, (XX. 3.), and from thence they came, in the course of their flight, to the passage of the Xanthus, *πρὸς Ἰχθυόεν*. (XXI. 2.). In so far the delineation, on M. CHEVALIER's map, is erroneous. H. See above, p. 56, 57. D.

‡ ILIAD, V. 713. et seq. Vid. STRABO, XIII. p. 890. A. 892. C.

|| STRABO says: "A little way before New Ilium the streams unite." It is doubtful, however, whether by this expression he means between Ilium and the sea, or on the inland side of the town.

§ ILIAD V. 36. VII. 329. XI. 498-9. ¶ Iliad, II. 465. 467.

ceives, at least in the more immediate vicinity of the city, the epithet of Trojan*. More precisely still it is said, (*Iliad*, VI. 1, &c.), "the battle raged between Simois and Xanthus." The latter must have been nearest the Grecian camp; for when the Trojans had advanced very nigh the rampart, and lay a night in the field before it, they are said to be between the camp and the Scamander. (*Iliad*, VIII. 556.). At the Scamander † HECTOR holds a council of war; and when the Trojans are compelled to retire from before the camp, the wounded HECTOR is laid down at the side of the Scamander. (*Iliad*, XIV. 433.). When, again, PATROCLUS drives the Trojans finally from the camp, he cuts off the retreat of a part of the fugitives to the city, forces them back towards the camp, and falls on them betwixt the station of the ships, the river and the city ‡. ACHILLES, in advancing from the camp to the Xanthus, drives a part of the flying enemy into the river; the rest escape to the town. (*Iliad*, XXI. 1. et seq.). Here it seems to be plainly intimated, that, on the way between the camp and the city, the river must be passed. And this is confirmed by several passages in the last book, where PRIAM, in going from the city to the Grecian camp, after passing the tomb of ILUS, arrives at the river,—undoubtedly the Scamander. Here he waters his horses. (*Iliad*, XXIV. 349.). In returning, he comes again to the same spot, (v. 692.); and here there

* *ILIAD*, X. 11. XXIII. 464. STRABO, p. 892. C.

† For this must be the ποταμός [ὁ] διὰ τῆς Ἰλίου of *Iliad*, VIII. 490.

‡ *ILIAD*, XVI. 397.

Here it is difficult to form a distinct idea of the topographical situation, unless we understand it thus: First, between the ships and the river; and farther on, between the river and the town.

there was a place for crossing the river *. HOMER guides us no farther.

I FORMERLY thought it probable that HOMER meant only a near approach of the two rivers, not an entire confluence of their streams; but this opinion I have long since abandoned. The Scholiasts, and even EUSTATHIUS, give us no aid here; they rather mislead; they themselves had probably no ocular knowledge of the place. The Scholia, however, on Iliad, II. 465. say, "the Scamander comes from Ida, divides in the midst the plain that stretches to the shore, and discharges itself, on the left hand, into the sea." But how is this to be understood? If the left hand *from Troy* is spoken of, the present mouth, to the southward of Sigeum, must be intended; and on that supposition this mouth would be of considerable antiquity. If the commentator, however, means on the left hand going *from the shore* to Mount Ida, it is then the united stream of the Scamander and Simois, that is said to fall into the sea at this place †.

EVEN

* 'Αλλ' ὅτι δὴ πρὸς Ἴδον ἕρποντες καταμύσσει.

—692.

It is here that M. CHEVALIER's observations on the spot, and his delineation upon the map, give us so much light. The Scamander, as it came near the shore, directing its course obliquely over the plain, approached the Simois, and run into it, exactly as described in STRABO. At present the Scamander is conducted into a canal, and discharges itself into the sea below Sigeum. This is one important observation made by M. CHEVALIER. There is another, also, relating to the sources of the Scamander. Still it is a perplexing circumstance, that, neither in the advancing, nor in the retreat, of the armies, is any express mention made of so important a circumstance as crossing the river. Almost all the passages, except perhaps the last, rather imply that the rivers run on each side. H. See above, p. 46. Note *. D.

† I DOUBT whether any of the poets, QUINTUS of Smyrna, TRYPHIODORUS, or COLUTHUS, had an accurate knowledge of this neighbourhood. TRYPHIODORUS, for instance, says, (lin. 316.),

Ἰαχὺ καὶ Εἰνθε ποταμὸν καταμύσσει ὄδῳ
καὶ ὁρμῇ κυλίσσει Σιμοίσιον.

"Loud

EVEN in STRABO's time the site of Old Ilium was unknown, and was a subject of dispute; but he marks out distinctly a *new* Ilium. Alexandria Troas was a different place from both, and lay more to the southward. New Ilium was twelve stadia (three-eighths of a German mile, somewhat less than two English miles) from the Grecian harbour. Thirty stadia (almost a German mile, or about four English miles and an half) higher up, eastward from New Ilium, and nearer Mount Ida, was situate Old Ilium, on a spot where then stood a village named Ilium*.

THE road from the city of Troy to the sea shore ran from the Scæan Gate, past a beech tree, to the tomb of ILUS, on which stood a pillar †. Another monument was called Baticia, or the tomb of the Amazon Myrinna, an insulated hillock, where the Trojans took post in the first battle. (Iliad, II. 811—15.). Upon another tomb, that of ÆSYETES, sat POLITES, as a scout on behalf of the Trojans. (Iliad, II. 793.). The Sca-

VOL. IV.

mander

"Loud roar'd the Xanthus, and the mouth of the Simois;" so they were not then united at the mouth. A little after, (lin. 319.), "They were dragging the wooden horse, but were retarded, the way being intersected by rivers, and very uneven."

Ὅδῳ δ' ἑκατέρωτο μακρῇ,
Ἐχέμεν ποταμοῖσι, καὶ ἑπιδίον ὁμίον.

* STRABO, XIII. p. 889. Ὁ γὰρ (ILUS) Ἰσταῖθα ἰδρυσα τὴν πόλιν οὗ νῦν ἴσται (New Ilium), ἀλλὰ οὐδὲν τί τριῶντα ἀνωτέρω πρὸς τὴν καὶ πρὸς τὴν Ἰδαν, καὶ τὴν Δαρδανίαν, (as this old habitation of DARDANUS lay still deeper in the mountains II. XX. 216, 217. northward from Old Ilium, STRABO, XIII. p. 891. D.) κατὰ τὴν οὖν καλεσμένην Ἰλίου κώμην. Compare p. 891. A. 892. D. When HOMER says of Ilium, *ἰσθίον πεδίοισι*, this is said in respect to Dardania, which lay among the mountains. Troy, however, actually stood at the *foot of the hill*, at the entrance of the valley or the plain.

† ILIAD XI. 166. 371. Here HECTOR had his post, on the night when he encamped before the Grecian camp. (X. 415.). Here PARIS stood behind the pillar, when he wounded DIOMEDE with an arrow. (XI. 372.). Just by the beech APOLLO stood near the city, and the place must likewise have commanded a view of the country. (XXI. 549.).

mander could not be far from the hillock where the tomb of ILUS was. (XXIV. 349. 350. Compare 692, 693.). Nearer the city, on the south-west side, and just under the walls, the Watch-tower must have stood, where the deities resorted*. Next to it was the wild fig-tree †, and the sources of the Scamander; and then the place where clothes were commonly washed ‡. Before the city, on the north side, was Callicoloné (καλή κολώνη), a pleasant hill upon the Simois, five stadia in circumference, and ten stadia from the village Ilium ||.

THAT it should still be possible, after such a lapse of time, to recognise all these places, is not to be expected; but there is one of them which we should think could even yet be traced, and which, if discovered, would furnish at once the most certain direction for all the rest, and even for the site of ancient Troy itself;—that is, the sources of the Scamander, so accurately and circumstantially described by HOMER, (XXII. 147. et seq.), the one of them a warm and smoking fountain, the other, even in

* Σκοπιὰ. (XX. 136.).

† Εφιδρία. (XXII. 146. XI. 167.). Quite close upon the walls, and at the place where they were so low that the Greeks had once attempted to force their way into the city from that quarter. (VI. 433—9.).

‡ See above, p. 44. D.

|| ACCORDING TO STRABO, (p. 802. D.), who borrowed this information from DEMETRIUS of Scepsis. The Venetian Scholiast A, upon Iliad, XX. 3, quotes the passage respecting Callicoloné, as if taken from the latter; but he mistakes this hillock for the θρασυὴς ὀρίδιον on the Scamander. He adds also, "Here it was that PARIS saw the three goddesses." At v. 53. the observation is repeated, more justly indeed, but in a mutilated form. In all other respects, the places hitherto mentioned are determined by M. CHEVALIER with great plausibility and distinctness. I find upon the map, which I had not an opportunity of seeing till too late, the hill Callicoloné more rightly laid down, than, from the words of the Memoir, I had supposed; (see p. 94.); and I retract what I there advanced. The passages respecting Callicoloné (XX. 53. 151.) are not, as I imagined, contradictory.

in the middle of summer, of an icy coldness. Yet even here there is a very great chasm in our topographical knowledge. At the place, where (according to DEMETRIUS of Scepsis, whom STRABO follows), the Scamander had its rise, one spring only was to be met with; and WOOD, with STRABO in his hand, sought and found this spring, and this alone*.

AFTER this preliminary sketch of the Topography of the Troad, let us now try whether it be possible to get a clear idea of the battles of the Greeks and Trojans.

THE first battle took place on the plain between Troy and the Grecian camp. The Greeks were drawn out in the Scamandrian plain. (Iliad, II. 467.). The Trojans, on the other hand, had taken post on the hill Baticia. (Iliad, II. 811. The engagement commences. PARIS and MENELAUS soon descry each other. HECTOR negotiates a combat between them, which is not attended with any decisive consequences. The armies must have been posted at no great distance from the city, for PRIAM, with his old men, sees from the walls the Grecian chiefs, and learns their names from HELEN †. The treacherous PANDARUS, by

* STRABO, p. 898.9. WOOD, p. 323-4. (98. of the German translation). And yet Mr WOOD did meet with a hot spring, but in a place where he was not looking for the Scamander. (p. 329.). M. CHEVALIER was more fortunate in this respect. He searched for and discovered the sources of the Scamander precisely at the hot spring; and thus cleared up the whole matter in doubt.

† THE distance, formerly stated, of the city from the shore, or more accurately from the harbour of the Greeks, making in all forty-two stadia, (one and one-fourth German, nearly five and one-half English miles), and the high commanding situation of the town, render this circumstance by no means improbable.

by discharging an arrow, brings on a general action. The Trojans attack the Greeks, (IV. 221.), and at length the armies close. (446.). The poet describes, as a poet must, individual combats only. (457, &c.). These however must have taken place in the neighbourhood of the city; for APOLLO surveys the combatants from Pergamos, and animates them by his shout. (IV. 507. V. 460. VII. 20.). For a long time the two armies alternately advance and retreat between the Simois and Scamander, (VI. 2, 3.), till AJAX at last makes the Trojans give way. When near the gate of the city, and not till then, they are rallied by the exertions of ÆNEAS and HECTOR, and again make a stand. (VI. 73, &c.). HECTOR, by the advice of HELENUS, and on account of the impending danger, as may be conjectured, has recourse to religious rites. He goes into the city, and gives directions for a female procession to the temple of MINERVA. In the mean time, a single combat between GLAUCUS and DIOMEDE terminates in a friendly parley. Upon the return of HECTOR, the battle is renewed. At length a single combat between HECTOR and AJAX is proposed. With this the narrative of the day closes. (VII. 1—306.). Both parties retire, the one into the city, the other to their camp. (VII. 310, &c.).

THE following day an armistice is agreed upon for burying the dead. The Greeks avail themselves of this interval, and rear in haste a rampart round their camp. (VII. 325, &c.). Of this more will be said by and by.

NEXT morning, by break of day, a new battle ensues; the second, on the plain between the city and the camp. (VIII. 60, &c.). Towards noon a panic spreads among the Greeks. They flee, and retreat in disorder to the very camp. (VIII. 68. &c. 139, &c. 213, &c.). At one time, indeed, they again advance to the charge; but still they are forced to give way; and at last shut themselves up in their camp. (336—343.). Fortunately for them night intervenes. (485, &c.).

HECTOR,

HECTOR, on this occasion, does not draw off his troops into the city, but makes them pass the night at the river, in the open air, at some distance from the camp*, and orders them to kindle watch-fires. By the advice of NESTOR, the Greeks likewise set a watch†. The same night a deputation is sent by the Greeks to ACHILLES, and ULYSSES and DIOMEDE set out on a scouting party. The situation of the Trojan encampment, at this juncture, is accurately delineated. (X. 415. 428.). HECTOR had assembled the chiefs at the tomb of ILIUS. The watch-fires, like the soldiers, were scattered over the field without any order. The troops extended themselves down to the sea, (probably the right wing of the Trojans pointed on the north towards Rhœteum, beyond the Simois), and some of their posts reached as far as Thymbra. At the outermost extremity lay the new arrived Thracians and RHESUS. (434.). This must have been towards the sea or the mouth of the Simois, and farther out before the Trojan army towards the Grecian camp; for ULYSSES and DIOMEDE, who surprised them, went along the stream of the Simois‡. The distance cannot have been great, for they set off a good while after midnight, and had returned to the camp by day-break.

NEXT

* Νέσφι νῦν ἀγαγὼν ποταμῷ ἐπὶ δύνῃσι. (VIII. 490.).

What river now could this be? The Scamander is termed δύνεις, eddying. The Simois, however, was still more so. Yet if the Scamander had its course obliquely thro' the plain, it must be the river here intended.

† IX. 67. Out at the tomb, λίξαδαι παρὰ τάφρον ὀρυκτὴν τεύχεος ἐκτός. It is more distinctly said afterwards, (v. 87.), between the tomb and the wall, καὶ δὲ μίσην τάφρον καὶ τεύχεος. Compare 180. 194. 198.

‡ HENCE we find mention made of the heron, (Iliad, X. 274.); of the tamarisks, (μυρίαι), and of the sedges, (466-7.). HOMER does not take notice of their passing the river. This, however, they must have done.

NEXT day the Trojans assault the Grecian camp. And here it becomes necessary to have some idea of the newly constructed fortification of the camp.

THE situation has been generally described already. The camp, according to my supposition, did not occupy the whole intermediate space, but only a part of the ground, between the two promontories Sigeum on the south, and Rhœteum to the north. Perhaps on this side it went no farther than to the Simois. By all appearances the camp must have had an oblique front, the right wing receding towards Sigeum, the left bending forwards, and hence more exposed to the enemy's attacks *.

As the Greeks in the first battle had not been successful, NESTOR proposes, during the truce agreed upon for burying the dead, to fortify the open camp. Such a precaution was before unnecessary; the Trojans having till now kept themselves shut up within their walls. NESTOR must now have been terrified at the superiority of the Trojans, and the valour of HECTOR particularly, when there was no ACHILLES to oppose him †. The idea of fortifying

* THIS representation seems to be corroborated by M. CHEVALIER's map.

† To give a historical probability to the circumstance of the Greeks having now, for the first time, thought of fortifying the camp, we must suppose, with THUCYDIDES, (I. 11.), that immediately upon their first landing they had beat back the Trojans, or, at least, that the latter fought their safety by remaining within their walls, while the Greeks were unacquainted with any means for carrying on a siege. In the above quoted passage of THUCYDIDES, I may observe, in passing, there is something which seems to contradict this explanation, *ἐπειδὴ δὲ ἀφικόμενοι μάχῃ ἐκράτησαν*, (δὲλοι δὲ τὸ γὰρ ἔργον τῷ στρατοπέδῳ ἔκ αὖ ἐτιμήσαντο), &c. One should think the *ἐκ* must be erased. Should it be said, THUCYDIDES may have understood the matter in a different light; the Greeks would not have been able to fortify their camp, had they not remained masters of the field. This is contradicted, first, by the time of their fortifying the camp, which took place in the tenth year; and, next, by the occasion of its being done: for it was when they were defeated that they first thought of fortification. The Scholiast says: This is to be understood of a former slight fortification. But that is a creature of his own fancy, which only serves to prove, that, even then, when he wrote, the *ἐκ* was to be found in the MS.

tifying the camp was then entirely new, and the plan for accomplishing it was singular enough. NESTOR advises to rear, for burning the dead, a common pile on the outside of the ships, and upon and round this pile to throw up a hillock, from which a wall and ditch should be drawn in front of the camp. The proposal is agreed to, (*Iliad*, VII. 327—343. 434, &c.), the pile is erected, the mound thrown up, and beside it a rampart constructed, (*Iliad*, XII. 29. 255, &c.), which the poet terms a wall, (*τείχος* and *πύργος*). (VII. 338. 436. et al.). It had battlements and breastworks, and was provided with gates, bastions, and turrets*. That all this was a very slight piece of work, may be supposed from the shortness of the time in which it was constructed. No wonder, then, if, in a short time, no trace of it remained. HOMER, by an ingenious and highly epic turn, ascribes its annihilation to NEPTUNE and APOLLO. (XII. 1, &c. 459, &c.). It was, however, the first attempt we know of to fortify a camp; and, in so far, is sufficiently remarkable to merit some attention.

A FEW elucidations respecting the work of this fortification may be added. That the mound was raised to the north-east, in front of the camp, can scarcely be doubted. Its position must therefore have been on the left wing, to which it must have served for a protection; and it may be supposed, that NESTOR, in proposing it, had this very end in view. But, as the river Simois ran on the same side, it is not clear what was the position of the mound in relation to the river, and what was the situation of the left wing, and particularly what was the position of the ships and of the post of AJAX with respect to both. In the assault on the camp, which took place on this wing, no mention is made either of the river or the mound. We only see that the rampart must have been constructed at a considerable distance before the ships; for here, between the ships

and

* *ἑτάλει πρεσβύτερος*. (XII. 259). Compare LYCOPHRON, 291. and the Scholiast.

and the rampart, a severe engagement ensued. (XIII. 136, &c. XIV. 30, &c.)*.

THE mound terminated in the rampart, properly a fence of earth, upon which turrets were erected, composed of beams and stones. (XII. 29.). That the rampart was low is clear, from the circumstance of SARPEDON's being able to catch hold, with his hand, of the battlements of the breast-work. The side on which the ships of AJAX were placed, is described as the lowest. (XIII. 682-3.). What QUINTUS says, (VII. 474.), has a reference to this circumstance.

THROUGH the rampart gates led into the plain†. Among these, it should seem, there was one principal gate, at the extremity of the left wing of the camp. Through it the Greeks marched out to battle. (XII. 118. Compare XIII. 326.).

ON the outside of the rampart, towards the plain, a ditch was drawn (VII. 341.) to break the first onset of the Trojans. In the ditch palisades were fixed‡.

THE fortification seems not to have extended along the whole front of the camp. We do not find, at least, that it reached to the

* THE poet indeed says, The mound was thrown up in the field, not far before the ships. (VII. 334. 433, &c.), *τοῦτον ἀπο πρὸ νῆων, — τύμβον ἀμφὶ πυρῆν, — ἐν πεδίῳ πρὸ δ' αὐτῶν, — πύργους ὑψηλὰς ἔλατ' ἡμῶν τε καὶ αὐτῶν.*

THE mound must have been thrown up *upon* and *round* the spot where the burning took place. Compare XXIII. 255, &c. and VIRGIL, *sepulchrum imponit*, VI. 292. in like manner upon the spot where the funeral pile had been erected; which is precisely what HOMER means by ἀμφὶ πυρῆν. In QUINTUS of Smyrna we find, in like manner, *πυρκαϊῆν καὶ τάφρον*, (read *τάφρον*). XII. 163, 164.

† Πύλαι. (VII. 339, 340. 438.). The Scholiast on v. 339. seems to be in the right, when he says, "On the left hand of the ship-station (*ναύσταθμός*) was a large "gate, besides which several other gates were constructed."

‡ VII. 441. XII. 54. 63, &c. Between the ditch and the wall no intermediate space was left, as may be inferred from VIII. 2, 3.; *τάφρος πύργῳ* must be united.

the quarter where ACHILLES was stationed. The oblique position of the camp must have been the cause of this. To the same circumstance we must have recourse to explain how, from the spot where the Trojans made a breach in the rampart, and at length set fire to a ship, the distance could be so great to the tents of AGAMEMNON, and the quarter where the remaining vessels were hauled up on the land*.

WE now come back to the assault of the camp. At day break the Greeks, leaving their chariots behind them, (XI. 48.), marched out from the camp. The Trojans had taken post on the field of battle, which had an acclivity towards Troy†. Till about noon the fate of the day was equivocal; but then the Greeks made the Trojans give way. The Trojans fled, past the tomb of ILUS, (XI. 166, &c.), through the midst of the plain, towards the wild fig-tree, (XI. 167.), and never stopped their flight till they had reached the beech tree and the Scæan Gate. (XI. 170.). Here the battle is renewed. (211, &c.). During all this day AGAMEMNON distinguishes himself, till he is wounded. On this the Trojans take fresh courage, repulse the Greeks, drive them back again past the tomb of ILUS, where PARIS lies in ambush, and wounds DIOMEDE with an arrow. (XI. 369, &c.). The combat spreads to a great distance over the plain, for HECTOR fought on the left wing, towards the Scamander, (XI. 498, &c.); against NESTOR and IDOMENEUS, and knew nothing of the defeat which DIOMEDE, ULYSSES and AJAX had given the Trojans towards the Simois. HECTOR flies to that quarter, and AJAX himself is now forced to fall back. (521, &c.). The Greeks flee to their camp, and shut themselves up in it. HECTOR pursues, and resolves to attack them in the camp, to break

VOL. IV.

* SEE Iliad, XIV. 30, &c.; a passage which I know not how to explain.

† *Ἐν τῷ ὄρει πρὸς τὴν πόλιν*. (XI. 56.); of which we have spoken already.

break in, set the ships on fire, and annihilate the whole Grecian army.

THIS operation was so new to the Trojans, that they did not know how to conduct the attack, so as to make themselves masters of the camp. At length, by the advice of POLYDAMAS; (*Iliad*, XII. 75.), the chiefs dismount from their chariots, and bring the infantry in five columns over the ditch. ASIUS alone remains in his chariot. He observes, upon the left wing of the ships *, the gate open, through which the Greeks had passed to and from the field. He makes an attack here, but with an unfortunate issue. (XII. 110, &c.). The other divisions assault at different points the rampart and the entrances. (175, &c.). As there were five columns of the Trojans, it is commonly supposed that the gates of the fortification must have also been five in number. HECTOR's division exert themselves to the utmost to demolish the rampart, (251.), particularly around and near one of the gates. (291.). SARPEDON assaults the rampart at the quarter defended by MENESTHEUS, leader of the Athenians. (331.). MENESTHEUS finds himself worsted, and calls for assistance to AJAX and TEUCER, who were engaged with HECTOR. By the absence of these two, HECTOR is left at liberty to act. He bursts the gate with a piece of rock, and forces his way into the camp. (437. et seq.).

THE terrified Greeks retreat towards their ships. Here the two AJAXES had joined. They rally the fugitives, and lead them on again against the enemy. This column of the Greeks appears to have some resemblance to a phalanx, the first outlines of which it is believed may be found here; for the bravest troops, we are told, drew up in thick closed ranks, and waited for the approaching foe. (XIII. 126, &c.). The enemy, by this manœuvre, is quickly repulsed.

WHILE

* Νῆες ἐν' ἀπὸρτην. (XII. 119.).

WHILE the battle rages here among the ships*, IDOMENEUS, accompanied by MERION, repairs to the left wing†, and there, with the vessels in his rear, makes head against the troops of ASIUS. The division commanded by ÆNEAS must have joined the column of ASIUS, and the troops of PARIS united with these two. At least, all the three detachments, as well as several others after them, must have formed a junction to oppose IDOMENEUS, in the place mentioned above. (XIII. 490.).

THE Trojans, in the mean time, began to crowd in on all sides round the place where HECTOR was engaged. By the advice of POLYDAMAS, (Ib. 726. et seq.), HECTOR calls the chiefs together to a council. He himself goes off, (Ib. 674. et seq. †. 754. et seq.), collects the bravest of the chiefs, with their battalions, and advances with them against AJAX. (789.).

MATTERS

* XIII. 312. Εἰς μίσητος ἡμεῖς.

† IBID. 326. Εἰς ἀριστερὰ στρατῷ. AJAX, as afterwards appears, fought in front of his own ships. The left wing of the camp, therefore, must have extended beyond the station of AJAX. Compare 679, &c. At that quarter, too, there were ships lying; for IDOMENEUS fought ἐπὶ πρύμνῃσι ἡμεῖς. (Ibid. 333.).

‡ A PASSAGE of considerable difficulty, in respect of the topography, occurs here. It is said, (XIII. 675.): "HECTOR knew not yet that, on the *left* hand of the ships, " ἡμῶν ἐπὶ ἀριστερὰ, his Trojans were suffering so much; but he still kept the place " where he had first penetrated into the camp, beside the quarter where the ships of " AJAX and PROTESILAUS were hauled up." (679—682.) The rampart, in front of the ships, was lowest at this spot. Here the action was sharpest. (v. 684.).

ἔνθα μάλιστα
Ζαχρηῖνός γίνοντο μάχη αὐτοὶ τε καὶ ἵπποι.

This last expression embarrasses me. How could chariots be of any use in the narrow space between the ships and the rampart? HOMER says further: "Here fought " the Boeotians, the Ionians, (Athenians), the Locrians, the Phthians," not those subject to ACHILLES, but those who had come with PROTESILAUS, out of Phylace in Thessaly, (II. 695.), but at this time fought under the command of PODARCES, (XIII. 693.), "the Epeans." I hardly think the ships of these people lay there,

but

MATTERS had now advanced so far, that HECTOR thought the completion of his wishes at hand, when the Grecian chiefs, after getting their wounds dressed, return to the combat. (XIV. 128. 365—387.). HECTOR is wounded, and the Trojans driven from the rampart to the outside of the ditch. (XVI. 12.).

HECTOR recovers again, rallies the Trojans, assaults the rampart once more, fills up the ditch, (Ibid. 355. et seq.), and renews the battle between the ships and the tents. (367. 384. et seq.). The Greeks beaten back take shelter behind and between the foremost row of the ships on the beach, and with their ship-poles ward off the Trojans as they press on. (Ib. 653. et seq.). AJAX boldly encounters HECTOR. At length HECTOR catches hold of the stern of a ship, belonging to the squadron of PROTESILAUS, and sets it on fire. (Ib. 704. et seq. XVI. 124. et seq.).

HERE the success of the Trojans stopped. PATROCLUS came forward to the combat. The Myrmidons, to the number of 2500, advanced in five divisions, drawn up in close columns*. The Trojans are defeated, and forced to retreat to the outside of the ditch. (XVI. 366. et seq.). There a complete flight ensues. PATROCLUS cuts off one part from the city, and destroys them betwixt the ships, the river, and the town†. Intoxicated with success, he pursues the fugitives, contrary to the orders of ACHILLES, to the very walls, and even attempts an assault upon the

but that the troops happened to come together in that place. Besides, so far as I can find, throughout this whole passage, even where HECTOR is spoken of, the *left* side must be understood as referring to the Grecian camp. It is so, where mention is made of PARIS, (v. 765.), as well as, in a preceding passage (v. 326.), of IDOMENEUS.

* XVI. 212. ACHILLES and his soldiers, we find, evidently excelled the rest of the Greeks in military skill. Writers on the art of war, PUYSEGUR for example, discover, in this arrangement of the troops led on by PATROCLUS, the first rudiments of cohorts.

† HERE occurs the remarkable expression formerly adverted to, *Μισσην ἡμῶν καὶ πατρὸς καὶ φίλου.* (XVI. 396. et seq.).

the city. (698—710.). HECTOR, having halted at the Scæan Gate, rushes again upon the Greeks and slays PATROCLUS. He pursues the flying Greeks to their camp; they bring off with them, however, the body of PATROCLUS. (XVII. 736.). The fight of ACHILLES, though unarmed, deters the Trojans from advancing farther.

THIS time too the Trojans pass the night in the open plain before the camp. (XVIII. 243. et seq.). HECTOR opposes the sage advice of POLYDAMAS, to retire into the city, and defend themselves behind the walls. (Ib. 274. et seq.). At day-break ACHILLES, clothed in new armour, comes out from the camp. (XX. 1. et seq.). The Trojans draw up on the rising ground* before the camp. This is the fourth and last battle. At first both armies display equal valour; but at length the Trojans give way, and fall back upon the Scamander. (Ib. 494. et seq.). Here ACHILLES separates the flying army. (XXI. 1. et seq.). One part are fortunate enough to effect their escape across the plain to the city. The remaining part he drives into the river, which, being choked in its course, swells and overflows its banks. ACHILLES now comes close up to the city, (Ib. 520.), which the flying Trojans had already entered by the Scæan Gate. (Ib. 526.). HECTOR alone remains before the town; and then ensues the single combat, in which HECTOR is slain by ACHILLES.

No. IV.

* *Εν τῷ πεδυνῷ τοῦ στρατοῦ*; before the camp. (XX. 3.).

No. IV. (p. 32.).

*The Reverend Dr JACKSON, Dean of Christ Church, Oxford, to
Mr DALZEL*.*

I CANNOT permit myself to leave Oxford for the summer, without paying you my very sincere thanks for the obliging manner in which you transmitted to me the present of M. CHEVALIER's Essay; and I beg you, when you have an opportunity, to present my acknowledgments to M. CHEVALIER himself: accompanied, however, with a little reproach, for his having forgotten the promise he made me, of calling at Oxford whenever he came to the south of England.

I HAVE had a very particular pleasure from the perusal of the work itself. No reader of HOMER could possibly be satisfied with the accounts we had before of the Troad; and Mr Wood's book, in particular, was idle and childish in the extreme.

IT was impossible, also, for the reader of HOMER to doubt of the situation of Troy, and the adjacent country, as described in the Iliad; and I had always, therefore, heard, from the few men who understood HOMER, one and the same language;—a language which I thoroughly adopted, that we were misinformed and mistaken as to the Scamander. And when I had the pleasure of meeting a set of friends, a few weeks ago, at Lord STORMONT's in London, I was not surprised to find that we all agreed in the same

* AT M. CHEVALIER's desire, Mr DALZEL sent a copy of the Essay to the learned and respectable Dean of Christ Church, (to whom M. CHEVALIER was known), and received the above answer.

same opinion, that M. CHEVALIER had cleared up our difficulties, and brought every thing into its right place, by discovering the true Scamander.—I have the honour to be, with perfect esteem and regard, &c.

CYR. JACKSON.

CHRIST CHURCH, }
July 7. 1792. }

The late Earl of MANSFIELD, (formerly Lord STORMONT), to Mr DALZEL.

I MUST not omit repeating my thanks for the Dissertation you were so good as to send me, which is upon a subject that has always interested my curiosity, and which I read twice in the course of last summer. [After a compliment to the Translation and Notes, his Lordship adds]:—I understand that you may soon expect an answer from a very ingenious gentleman*, but one who doubts even of the existence of the Trojan war. I can venture to foretel that he will not shake my faith, which is, and long has been, that HOMER rested upon historical tradition, not only for the principal facts, but also for the leading differences in the characters of his heroes; and that they know little of his real excellence, who ascribe to him that sort of invention, which is the paltry merit of a modern writer of romance.—I am, with great esteem, &c.

MANSFIELD.

PORTLAND-PLACE, }
June 17. 1793. }

No. V.

* THIS proved to be the learned Mr BRYANT.

~~some opinion, that M. CHEVALIER had cleared up our difficulties
and brought every thing into its right place by his over-
ing the true Scamander.—I have the honour to be, with perfect
esteem and respect, Sir, Your obedient servant, J. HAWKINS.~~

No. V. (p. 33. 39. 41. 45. 48. 52. 65.).

ROBERT LISTON, Esq; *His Britannic Majesty's Ambassador at Constantinople, to Mr DALZEL, Greek Professor in the University of Edinburgh.*

MY DEAR FRIEND, *Constantinople, Sept. 25. 1794.*

To day I have not time to say a single word with regard to myself: but I cannot avoid the temptation of sending you copies of letters from gentlemen who lately left me, and at my request promised to inspect the Troad with attention. They are both ingenious men. Dr SIBTHORPE is Professor of Botany in Oxford: The other, noted for his knowledge in mineralogy, and his geographical researches, a brother of Sir CHRISTOPHER HAWKINS.

You will be glad to see their observations tend to confirm M. CHEVALIER's system. I ever am most cordially yours,

ROBERT LISTON.

J. HAWKINS, Esq; *to his Excellency ROBERT LISTON, His Britannic Majesty's Ambassador at Constantinople.*

*At Anchor, opposite Karanlik-limani,
Sept. 15. 1794. Monday Eve.*

I SEIZE the first opportunity of giving your Excellency some account of our expedition to the Troad, but the time will not permit to enter into particulars.

WE

WE cast anchor at *Kaum-kaleb*, about mid-day, on Saturday, engaged horses, and crossed the plain in three hours to the village of *Bounar-basbi*, where we slept. We spent the whole of the next day in visiting the hill, which M. CHEVALIER supposes to have been the site of Troy, and the springs of water, which he considers as the fountains of the Scamander. A day, I think, is fully sufficient for this purpose, unless the traveller means to make topographical observations, which was the case with me.

WE were well lodged and entertained in a *Chiftlik* at *Bounar-basbi*, belonging to HADGI MEHEMET BEY, a person of some consequence, who actually resides at the Dardanelles, but is now on a pilgrimage to Mecca. His substitute or steward received us in a manner which left us nothing to wish for; and our arrival there seemed to cause no surprise, as they were accustomed to *frank* visitors. We returned by a different rout this day, visiting the tomb of *ÆSYETES*, (see CHEVALIER's map), and those near Cape *Jenitcheri*, supposed to be of *ACHILLES* and *PATROCLUS*.

YOUR Excellency naturally wishes to hear our present sentiments respecting the hypothesis of M. CHEVALIER. We still think it a very plausible one; and although his map is incorrect in the detail, it gives a pretty good idea of the Troad in general. He has certainly pitched upon a place for the site of old Troy, which has much natural strength to recommend it, particularly the easternmost angle of the hill, which, from its height above the Simois, and its peninsular form, must have been considered as a very strong natural fastness in those times of warfare, and could have been easily rendered an impregnable citadel; for it is not large enough for the site of the whole city. Some *tumuli* near this spot are certainly strong indices.

THERE are two places distant from each other about two hundred yards, in which the supposed Scamander issues out of the

earth ; in each, however, by many mouths. The water proved equally cold in them all : nevertheless in winter one is said to be warm.

WE saw the place where the course of this river is diverted by an artificial canal to the Archipelago. We are now about to shape our course for *Samothraki*. The bearer, our janissary, sets out also on his return to the Dardanelles, where he will consign this to the care of our Consul, to whose great attention and civilities, as well as to those of his uncle Mr KAIM, we are much indebted.

I BEG leave to add, how much I am flattered by the civilities paid me at Constantinople, and with what truth I have the honour to be, &c.

J. HAWKINS.

Dr JOHN SIBTHORPE, *Professor of Botany in the University of Oxford*, to his Excellency ROBERT LISTON, *His Britannic Majesty's Ambassador at Constantinople*.

DEAR SIR,

Troy, Sept. 15. 1794.

I AM just returned from Troy, as persuaded as a faithful Muffulman who has made his pilgrimage to Mecca, or as a pious crusader who has been at Jerusalem, that my eyes have beheld the tombs of those mighty heroes HOMER has sung near two thousand years since. It was the "*Campus ubi Troja fuit*." The piety of former ages raised tombs more lasting than marble or brass, which time has not destroyed. Troy and its temples have been so completely rased, that not a column, or even a stone that has been used in architecture, remains to tell its site ; and it is from the *tumuli* only, with their relative situation to the Simois and Scamander, that we are to learn where it once stood.

flood. The situation where we suppose the citadel to be, is particularly steep and rocky. It is girt by the Simois, the bed of which is now entirely dry. Perhaps the winter torrents might raise it into a considerable river. Its banks are fringed with planes, agnus castus, and tamarisk. We slept at *Bounar-basbi*, a little below which rises the Scamander, fed by numerous springs of a pure crystalline water. One of those is said to be warm in winter. At present it communicated to us no sensation of heat. The course of the Scamander is often interrupted and choked up. It had overflowed the adjacent lands, which were become reedy, and offered a favourable situation to wild ducks, snipes, and coots. The plain of Troy is rich and fertile. We traversed it from *Koum-kaleb* to *Bounar-basbi*, an extent of nine miles, and slept at the house of the Aga. He was himself gone to Mecca, but his *homme-d'affaires*, or steward, received us with much hospitality. Your Excellency will find it the best situation to sleep at, when you visit the Troad. Troy seems to have been built on a most rocky spot. We could not find on it even a spring of water. It is covered with prickly barnet, and a few thorny shrubs. The almond tree, which grows wild, is not without its thorns. It has even more pleasing plants, the yellow jasmine and the wild olive.

I WRITE to your Excellency in haste, our vessel tossing about at anchor opposite the tomb of AJAX, where it has been just drove by a hard gale of wind. The janissary, who accompanied us from the Dardanelles, is waiting for my letter. He was recommended to us by our Consul, and has done credit to the recommendation. In appointing Signior TARAGANO, your Excellency has nominated a Consul very desirous to oblige and render every service to his countrymen. &c.

JOHN SIBTHORPE.

*A second Letter on the Subject of the Troad, from his Excellency
ROBERT LISTON, LL. D. F. R. S. EDIN. His Britannic Ma-
jesty's Ambassador at Constantinople, to Mr DALZEL, Professor of
Greek in the University of Edinburgh.*

MY DEAR FRIEND, *Constantinople, April 25. 1795.*

YOUR letter of the 28th of December reached me after a long delay, occasioned by the interruption of the communication through Holland.

IT gives me pleasure to observe, that the circumstances I transcribed for you, on the subject of the Troad, appeared interesting. I have since had another letter from Mr HAWKINS, which confirms still more perfectly the topography of CHEVALIER, by removing the only difficulty that could possibly cause hesitation; a difficulty which had been proposed to me in so positive a manner, as to make an impression on my mind, deeper (it seems) than it ought to have done. As I have not as yet any near prospect of visiting the spot myself, I will once more copy from Mr HAWKINS.

"I AM extremely happy" (says he) "that our communications respecting the Troad proved so satisfactory; and I am happy that it is in my power to remove the only remaining doubt expressed in your letter, by assuring your Excellency, that Tenedos is really to be seen from the hill of Troy; even the whole coast of the island is visible from the northern to the southern point."

"THE most essential point, in substantiating the evidence of CHEVALIER, is that of the canal made to divert the waters of the Scamander from their original course towards the Simois."

"This

" This canal we can bear testimony to. The errors of Wood
 " seem to arise from the overlooking this circumstance. As for
 " STRABO, he had never visited the spot in all probability, and
 " relied on the authority of DEMETRIUS of Scepsis.

" At Athens we fell in with Mr FAUVAL, a very ingenious
 " artist, long in the service of M. DE CHOISEUL, who assured us,
 " that M. CHEVALIER's account of the goblet, discovered in the
 " tomb of ACHILLES, is perfectly fabulous. It originated, it
 " seems, from the fragments of a small bronze figure, which,
 " when he had cleaned, and put together, proved to be a very
 " curious image of MINERVA. He shewed us a cast which he
 " had made of it in plaster of Paris.

" This gentleman shewed us some *genuine* Etruscan vases,
 " discovered in *tumuli* he had opened in Attica. This will throw
 " new light on the history of art. For my own part, I consider
 " the Etruscan as nothing else than the early Greek style."

I HAVE copied more than I intended when I took Mr HAWKINS's letter into my hand; but you will think probably that the whole is interesting. Ever most truly and cordially yours,

ROBERT LISTON.

No. VI. (36. 55, 56, 57. 62. 72.).

M. CHEVALIER to Mr DALZEL.

MONSIEUR ET CHER AMI, *Londres, ce 11 Avril 1796.*

J'AI reçu votre réponse du 2, et j'ai été enchanté d'apprendre
 que M. l'Ambassadeur LISTON avoit prit la peine d'aller vérifier
 lui-

lui-même mes observations sur la plaine de Troye. Son témoignage fera du plus grand poids dans la dispute qui s'élève entre le Dr BRYANT et nous. Quant aux fautes qu'il a trouvées dans la Carte, je ne demande pas mieux qu'on les corrige, et je prête de tout mon cœur les mains à toutes les améliorations dont cet ouvrage est susceptible; mais je ne crains pas de vous assurer d'avance, que les changemens qu'on pourra faire ne sauroient tomber sur des monumens essentiels à l'intelligence de l'Iliade, tels que la situation de l'ancienne Troye, les sources du Scamandre, les tombeaux des guerriers, les caps, &c. Tous ces points sont fixés relativement les uns aux autres, avec assez de précision pour que les changemens qu'on y fera ne puissent pas affecter sensiblement mon ouvrage. Quant aux monumens modernes, tels qu'Alexandria Troas, &c. j'avoue que je n'ai pas cru qu'il fut nécessaire de les traiter avec une aussi scrupuleuse attention. La ligne de la côte a été faite avec la plus grande exactitude; ainsi que l'embouchure de l'Hellespont et l'île de Ténédos. Je doute, en conséquence, que la nouvelle carte y fasse aucune alteration.

Au reste: encore une fois je vous donne carte blanche, et de tout mon cœur. Vous pouvez couper, tailler, rogner à votre fantaisie.

LORSQUE vous publiez la seconde édition, mon ami, vous m'obligerez beaucoup de vous souvenir du petit nombre d'observations que je vais vous faire; ou plutôt, que je crois déjà vous avoir faites.

Je desirerai, d'abord, que vous supprimiez ma tirade contre les princes et les femmes voyageurs. Je desirerai, en seconde lieu, que l'autre tirade contre les prêtres des premiers Chrétiens soit aussi supprimée; et Mr BRYANT vous en a dit la raison. 3^o, Tout le chapitre du *throsmos*, et du tombeau d'ILUS, ne vaut rien. Mr HEYNE m'a suggéré autrefois une très excellente idée sur ce *barrow* qu'on voit sur les bords du Simois, en avant le camp

camp des Grecs. Ce monument est certainement le *tombeau commun* que les Grecs éleverent à leur soldats tués dans le combat. Vous voudrez bien profiter de cette idée, et l'arranger à votre façon. Un tombeau si voisin du camp des Grecs ne pouvoit pas être un tombeau Troyen. —

ADIEU, mon ami, vous aurez encore une fois des mes nouvelles avant mon départ.

LE CHEVALIER.

M. CHEVALIER to Mr DALZEL.

MONSIEUR ET CHER AMI,

Londres, ce 5 Mai 1796.

***** Je joins ici les corrections que vous m'avez demandées, et qui sont beaucoup trop longues pour être écrites à la marge d'un de nos livres, comme vous aviez paru le desirer.

1^{mo}, J'insiste surtout sur la suppression totale du Chapitre 16. page 112. de la traduction Angloise, qui traite du tombeau d'ILUS. Il est évident que je me suis grossièrement trompé ; premièrement, en confondant le *Σπασμὸς* avec le tombeau d'ILUS ; et secondement, le tombeau d'ILUS avec le monument que j'ai decouvert près des ruines du pont, à peu de distance de l'embouchure du Simois. Mr HEYNE, qui fait beaucoup mieux l'Iliade que moi, avoit soupçonné que ce monument pouvoit bien être le *tombeau qu'on éleva en commun* aux soldats Grecs après le premier combat, et dont il est question dans le 7^e livre, vers. 334. &c. Il me fit part de ses idées, que j'adoptai sur le champ, et c'est ce qui lui a fait dire, page 168. de sa traduction Allemande, dans une des notes, que M. LE CHEVALIER, n'étoit pas éloigné de croire que ce tombeau, au lieu d'être celui d'ILUS, étoit vraisemblablement

blement le tombeau commun. En effet ce tombeau commun n'étoit pas loin des vaisseaux, puisqu' HOMERE le place,

Τυτδαν ἀπὸ πρὸ νεῶν, — Iliad, VII. 334.

et que le retranchement fut bâti tout près de lui. Ces circonstances s'accordent fort bien avec la situation du monument decouvert près des ruines du pont.

2^{do}, Je desirerois aussi que vous supprimassiez tout-à-fait le passage qui a rapport aux princes voyageurs; vous n'imaginerez jamais qu'il y a eu des personnes assez malveillants pour m'accuser d'avoir voulu faire des applications auxquelles vous savez que je n'ai jamais songé.

3^{to}, J'ai dit, à la page 12, que du sommet d'*Udjek-tepè* j'avois aperçu à l'ouest la mer Egée, les îles de Tenédos, d'Imbros, de Samothrace, et de Lemnos; j'ai dit, de plus, à la page 36. qu'en arrivant à *Koum-kalè* avec M. CASAS, j'avois encore remarqué les mêmes pics d'Imbros et de Samothrace, &c. Lorsque je faisois cette observation, j'ignoroit entièrement qu'HOMERE l'avoit justifier dans le 13^e livre de l'Iliade, vers. 11, &c. où il représente NEPTUNE observant les combats du haut du pic de Samothrace; Car de là, dit il, on apperçoit toute la chaîne de l'Ida :

Καὶ γὰρ ὁ θαυμάζων ἦτο πόλεμόν τε μάχην τε
 Ὑψὲ ἐπ' ἀκρότατης κορυφῆς Σάμῃ ὕληςσιν
 Θρηϊκίης ἔνδον γὰρ ἔφαινετο πᾶσα μὲν Ἴδη, —

La marche de NEPTUNE, quand il quitte Samothrace pour se rendre au camp des Grecs, s'accorde aussi très bien avec mon observation; car il laisse ses chevaux à moitié chemin, entre Imbros et Tenédos :

Μεσσηγὺς Τενέδοιο καὶ Ἰμβροει παυπαλοίσσης. Ibid. 33.

4^{to}, Du moment où nous supprimons entièrement le chapitre qui traite du tombeau d'ILUS, je n'ai pas besoin de vous avertir qu'il faut supprimer le même tombeau, encore mentionné à la page 63. comme faisant encore aujourd'hui partie des monumens cités par STRABON.

VOILÀ, mon ami, tout ce que je puis vous dire en poste pour le moment. Recevez, pour la dernière fois, mes sinceres remercimens pour toutes les marques d'amitié que vous m'avez données ; et comptez sur la mienne à la vie à la mort. J'attends de jour en jour mon passeport ; aussitôt qu'il arrive je me mets en route. Mes complimens à tous nos amis. Adieu.

LE CHEVALIER.

END OF THE FOURTH VOLUME.

170. Du moment où nous supposons enlever le chapitre qui traite du tombeau d'Alain, je n'ai pas besoin de vous avertir qu'il faut supprimer le même tombeau encore mentionné à la page 63, comme faisant encore aujourd'hui partie des monuments cités par STRABON.

Voilà, mon ami, tout ce que je puis vous dire en cette pour le moment. Recevez, pour la dernière fois, mes amicales remercîmens pour toutes les marques d'amitié que vous m'avez données; et compay sur la mienne à la vie à la mort. J'attends de jour en jour mon passage; au lieu qu'il arrive je me mets en route. Mes complimens à tous nos amis. Adieu.

LE CHEVALIER

END OF THE FOURTH VOLUME

E R R A T A.

HISTORY.

Page 17. line 12. for *flots*, read *floats*.

30. line last, for last Article, Part II. read last Art. Phys. Cl. Part II.

PART II. PHYS. PAPERS.

Page 111. line 4. from the bottom, for M, read N.

12. from the bottom, for Join AH, read Join EH.

119. 4. from the bottom, for APPOLLONIUS read APOLLONIUS.

120. 11. from the bottom, for hence the quadrilateral, read hence, if AG, GK be joined, the quadrilateral, &c.

132. 6. from the top, for fig. 20. Pl. IV. read fig. 13. Pl. II.

N. B. In Pl. IV. fig. 18. the points B and K must be joined by a straight line.

135. This Paper is by mistake numbered V. instead of VI. and the same error is continued in numbering the remaining Papers of the Phys. Cl.

138. line last. for the latitude here given, viz. $57^{\circ}. 9'. 1''$, read $57^{\circ}. 8' 59\frac{1}{2}''$, the sun's semidiameter, used in the reduction of the observations, having been $1\frac{1}{2}''$ too great.

178. 6. instead of the term $\frac{1^2}{2} \cdot e$, read $\frac{1^2}{2} \cdot e^2$.

193. 4. from the bottom, for quilt-like read quill-like

PART. III. LIT. PAPERS.

Page 86. line 21. for ACHILLES, read PATROCLUS,

101. 5. from the bottom; Notes, for tomb read trench

DIRECTIONS FOR THE BINDER.

THE Binder is desired to observe, that this Vol. consists of Four Sets of Pages, to be arranged, after the TABLE OF CONTENTS, in the following Order, viz. : PART I. containing the HISTORY OF THE SOCIETY, with the Pages regularly numbered as far as 40; and afterwards going on with the numbers included between parenthesis, thus (1), &c. to the end of PART I. Then follows PART II. consisting, 1st, Of PAPERS OF THE PHYSICAL CLASS, with the Pages numbered in one Series; and, 2dly, PAPERS OF THE LITERARY CLASS, with the Pages numbered in another Series. The Binder will also observe, that there are in all 13 PLATES, 6 for the PHYSICAL CLASS, and 7 for the LITERARY, which are to be placed exactly according to the references marked on the margin of each.